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Assessment of Risk Associated with the Minnesota Proposed Plan for Split-State Status for *Mycobacterium bovis* (Bovine Tuberculosis)

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Risk Analysis Team

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Acronyms

AF	Accredited Free
APHIS	Animal and Plant Health Inspection Service (USDA)
BAH	Board of Animal Health (MN)
CCC	Commodity Credit Corporation
CEAH	Centers for Epidemiology and Animal Health
CCT	Comparative cervical test
CFR	Code of Federal Regulations
CFT	Caudal fold test
DNR	Department of Natural Resources
MA	Modified Accredited
MAA	Modified Accredited Advanced
MPCA	Minnesota Pollution Control Agency
NAHMS	National Animal Health Monitoring System (APHIS)
NASS	National Agricultural Statistics Service (USDA)
PCR	Polymerase chain reaction
PMO	Pasteurized Milk Ordinance
TB	Tuberculosis
UM&R	Uniform Methods and Rules (Bovine Tuberculosis Eradication)
USDA	United States Department of Agriculture
VS	Veterinary Services (APHIS)
WHT	Whole-herd test
WS	Wildlife Services (APHIS)

Executive Summary

In July 2005, a Minnesota beef herd tested positive for *Mycobacterium bovis (M. bovis)* and was officially declared infected with bovine tuberculosis (TB). This was the first infected herd identified since Minnesota's Accredited Free (AF) status was obtained in 1976. Subsequent testing identified infection in white-tailed deer and several cattle herds adjacent to this index herd. In February 2008, Minnesota declared its 11th infected cattle herd, resulting in the downgrade of the entire State's TB status to Modified Accredited (MA).

In an effort to minimize the impact of MA status to the State and producers, Minnesota initiated the process for split-State status application. Minnesota is currently in the process of writing its final application, but has submitted a proposed plan to the United States Department of Agriculture's (USDA) Animal and Plant Health Inspection Service (APHIS) Veterinary Services (VS) for review. The Risk Analysis Team at USDA:APHIS:VS Centers for Epidemiology and Animal Health (CEAH) was asked by the VS Eastern Region office to conduct a risk assessment of Minnesota's proposed plan for split-State status. In its plan, Minnesota outlines an area containing 300 cattle herds to be designated the MA zone. In addition, Minnesota is proposing the rest of the State be considered Accredited Free.

The objectives of this assessment are:

1. To determine if there is sufficient evidence to demonstrate the absence of *M. bovis* in cattle and other potential hosts in the proposed AF zone; and
2. To evaluate the adequacy of Minnesota's proposed plan to:
    a. Prevent the future release of *M. bovis* from the proposed MA zone; and
    b. Detect the future introduction of *M. bovis* in the proposed AF zone.

The three major risk pathways evaluated for transmission of *M. bovis* out of the proposed MA zone were: (1) the movement of cattle; (2) the movement of potentially infected white-tailed deer and other wildlife; and (3) the movement of potentially *M.bovis*-contaminated feed and other fomites.

In addition, the following questions were discussed:

1. Is active transmission of *M. bovis* still occurring in white-tailed deer or cattle in the proposed MA zone?
2. Are all identified areas of high risk currently contained within the proposed MA zone?
3. Is Minnesota's plan for split-State status sufficient to mitigate all risk pathways for future transmission of *M. bovis* outside the proposed MA zone?
4. Has adequate sampling been conducted in the proposed AF zone to demonstrate livestock and wildlife are not at risk of being infected with *M. bovis*?
5. Are future surveillance efforts in the proposed AF zone sufficient to demonstrate the design prevalence required in 9 CFR 77, based on potential risks in that zone?
6. Does the State have the necessary financial resources to implement and enforce the proposed split-State plan?

Based on a review of all currently available data, this assessment identified several areas of concern for the release and detection of *M. bovis* in the proposed AF zone. The conclusions of this risk assessment are as follows:

- *M. bovis* transmission appears to be active in cattle and white-tailed deer inside the proposed MA zone. It is unknown if other wildlife play a role in the disease transmission cycle. A significant portion of historic cattle movements and potential white-tailed deer dispersal movements, from the areas where *M. bovis* has been detected, are not included in the proposed MA Zone.

- The sampling of cattle herds in the proposed AF zone was completed in 2007 and was sufficient to detect a design prevalence of 0.2-percent with 95-percent confidence when all 3 years of sampling data are combined (2005-07). However, potential exposure of cattle herds outside the proposed MA zone has continued due to unrestricted movement of cattle and feed, and possibly white-tailed deer. Furthermore, trace investigations from the recently discovered infected herds were not complete at the time of this writing. Additional surveillance in the proposed AF zone is necessary to demonstrate the absence of *M. bovis* in cattle.

- The one-time hunter-harvested sampling of white-tailed deer in the proposed AF zone, particularly in those areas bordering the proposed MA zone, does not provide conclusive evidence that *M. bovis* is not present in white-tailed deer outside the proposed MA zone. In addition, the risk of *M. bovis* transmission into the proposed AF zone will continue after the implementation of the proposed split-State plan through the movement of cattle and feed (e.g., hay), and dispersal of white-tailed deer. Additional mitigation efforts could help reduce the risk of feed as a fomite. A targeted surveillance program in high-risk areas in the proposed AF zone is needed for the rapid detection in the event of *M. bovis* introduction.

- The proposed budget and anticipated funding are adequate for implementation of the split-State plan. The benefits that implementation of the split-State plan will provide Minnesota are greater than its costs. The split-State plan is a step to help Minnesota work toward the goal of eventual eradication of *M. bovis* in cattle.

Section 1: Introduction

1.1 Background

Bovine tuberculosis (TB) was responsible for more losses among U.S. farm animals in the early part of the 20th century than all other infectious diseases combined. The Cooperative State–Federal Tuberculosis Eradication Program began in 1917 to eradicate bovine TB from the Nation's livestock population. This program, administered by USDA:APHIS, State animal health agencies, and U.S. livestock producers, has nearly eradicated bovine TB from the United States. Currently all States are designated as Accredited Free (AF) with the exception of Minnesota and parts of Michigan and New Mexico. The recent findings of bovine TB in these three States demonstrate the need for continued efforts for successful eradication of *M. bovis*.

In July 2005, a beef cattle herd in Roseau County, MN, was identified as infected with bovine TB through routine slaughter surveillance. This was the first positive herd identified in Minnesota since 1971, 5 years before the State was declared free from bovine TB. Subsequent testing revealed infection in several adjacent and epidemiologically linked cattle herds, as well as free-ranging cervids. In February 2008, Minnesota declared its 11th positive cattle herd. On April 9, 2008, USDA announced the official downgrade of the State to Modified Accredited (MA) status according to USDA's program standards for bovine TB (USDA:APHIS 2005).

In an effort to reduce the impact of MA status to producers and the State, Minnesota's Board of Animal Health initiated the application process for split-State status with USDA in January 2008. Minnesota is currently completing its application; therefore this risk assessment will not evaluate Minnesota's complete application, only the plan provided to this risk assessment team on March 11, 2008. In its proposed plan (Appendix 5), Minnesota outlines a 17,738.8 sq km (6,849.0 sq mi) zone, which includes 300 cattle herds, to be the designated MA zone. This zone is based on the location of wild cervids and cattle herds infected with bovine TB in 2006. In addition, Minnesota is requesting the rest of the State be considered Accredited Free, based on the lack of finding bovine TB in the statewide testing of 1,550 herds conducted through the end of 2007. A one-time statewide hunter-harvested surveillance program (during fall 2006) has also been conducted, in an attempt to further demonstrate Minnesota's *M. bovis*-free status in wild cervids outside the proposed MA zone.

Under the Code of Federal Regulations (CFR), Title 9 Part 77, States may request zoning of an area for bovine TB if the State meets USDA's requirements. These requirements include the adoption and enforcement of regulations that impose restrictions on the intrastate movement of cattle, bison, and captive cervids in compliance with USDA's interstate movement requirements. The zone size must also be adequate to prevent the interstate spread of bovine TB.

In order to be considered accredited free, a zone must have adequate surveillance to demonstrate that cattle and other potential reservoir hosts are not at risk of being infected. Measures must also be in place to ensure that the spread of *M. bovis* outside the proposed zone is sufficiently mitigated. This decision is based on a risk assessment conducted by USDA. Continued annual surveillance in cattle in this zone must be sufficient to detect 2-percent design prevalence with 95-percent confidence (USDA:APHIS 2005).

The Risk Analysis Team at USDA:APHIS:VS:CEAH was asked to assess the risk associated with Minnesota's proposed plan for split-State status. This risk assessment will help guide USDA decision makers during Minnesota's application process.

1.2 Objective

The risk assessment of the Minnesota proposed split-State plan (Appendix 5) will evaluate:

1. The risk of *M. bovis* spread from the proposed MA zone, given the outlined mitigation efforts; and
2. If adequate surveillance has been conducted to demonstrate the absence of *M. bovis* in the proposed AF zone based on ecologic, geographic, and other epidemiologic risk factors in the targeted populations.

The Risk Analysis Team, along with members of CEAH's Spatial Epidemiology Team, completed this assessment in collaboration with Minnesota's Board of Animal Health (BAH), Minnesota's Department of Natural Resources (DNR), USDA:APHIS:VS and Wildlife Services (WS) Minnesota. Additional input was provided from Minnesota's Department of Agriculture, University of Minnesota, and others by request.

1.3 Assumptions

The application for split-State status is a lengthy process based on the 11 risk factors outlined in 9 CFR 92.2. Based on the limited time to conduct this assessment, all 11 risk factors are not evaluated here. This assessment focuses only on those risk factors associated with the biological spread of bovine TB from the proposed MA zone to the rest of Minnesota or other States, based on the information provided by Minnesota. A complete application including the 11 risk factors will be submitted to VS personnel for further evaluation.

This risk assessment assumes that Minnesota meets all the requirements under 9 CFR 77, including the resources necessary to implement and enforce a TB eradication program. It also assumes that the infrastructure, laws, and regulations are or soon will be in place to ensure that State and Federal animal health authorities are notified of TB cases in domestic livestock or outbreaks in wildlife.

In addition, this assessment assumes Minnesota's plan is compliant with regulatory guidelines for animal movement or other issues of regulatory concern. The regulations outlined in 9 CFR and the 2005 Uniform Methods & Rules (UM&R) are considered acceptable in the context of risk.

1.4 Methods

This risk assessment adopted the standards outlined by USDA:APHIS for a risk assessment review to evaluate the sanitary and phytosanitary risk of imported commodities. A risk assessment is an unbiased, scientifically defensible document that communicates issues of concern; regulatory options under consideration; evidence to support the assessment; analytical methods used; and conclusions of the assessment to policy makers, stakeholders, trading partners, and the general public (USDA:APHIS 2001).

A risk assessment is one step in the risk analysis process and serves to inform the risk management process. The process of risk management determines the acceptable level of risk and uses the results of the risk assessment to formalize the decision-making process.

The risk assessment includes hazard identification, release assessment, exposure assessment, consequence assessment, and an overall risk estimation (OIE 2008). The process of assessing risk associated with the application for regionalization is obtained from 9 CFR 92.2 and 9 CFR 77.3. During a regionalization process it is the responsibility of the party applying for regionalization to provide the risk assessor with the tools necessary to adequately evaluate risk. Minnesota initiated the split-State status application in spring 2008 and hopes to have the final approval by fall 2008; therefore, adjustments had to be made in the risk assessment process. This risk assessment only evaluates Minnesota's plan as of March 11, 2008, rather than Minnesota's final application for split-State status. Minnesota is still in the process of writing the application for split-State status.

Given the timeline for this assessment, quantitative analyses were used when possible. Additional analyses are needed to better estimate the overall risk associated with each potential exposure event and the likelihood of these events occurring.

The Minnesota BAH provided data on trace events from the 11 infected herds as well as the TB testing data from all herds tested between May 2005 and March 2008. These data were used to evaluate the risk of *M. bovis* spread based on animal movement and the effectiveness of the statewide surveillance efforts. The BAH also provided spatial locations of livestock and captive cervid premises in the State, which helped establish a description of the populations at risk.

The Minnesota DNR provided data on population densities and wild cervid testing for bovine TB. This information was used to evaluate the current wild cervid sampling efforts.

Economic data were provided by many resources including the BAH, DNR, Minnesota Department of Agriculture, USDA:APHIS:VS:Eastern Region and the University of Minnesota.

A scientific literature review was conducted and provided additional resources for the evaluation of the split-State status plan. Supporting documentation for this assessment included the Census of Agriculture (National Agriculture Statistics Service [NASS]), VS Memos and Notices, OIE guidelines, additional documents provided by BAH, and many other publically available resources.

The primary documents used as guidance for this assessment include:

- Code of Federal Regulations (9 CFR 92.2 and 9 CFR 77–current as of February 7, 2008);
- USDA:APHIS:VS UM&R (Bovine Tuberculosis Eradication), January 2005;
- Minnesota Split-State Plan (March 11, 2008); and
- Minnesota Bovine Tuberculosis Management Plan (2006)

Section 2: Hazard Identification

The risk analysis process is initiated by identifying the hazards (OIE 2008). To fully evaluate the risk associated with Minnesota's plan for split-State status, a thorough knowledge of the infectious disease agent affecting the species at risk is crucial.

2.1 Agent

Mycobacterium bovis (M.bovis) is the primary agent responsible for bovine TB, a chronic, granulomatous disease in domestic and wild animals. *M. bovis* is a slow-growing, acid-fast, Gram-positive, rod- to filamentous-shaped bacteria. *M. bovis* has a very broad host range and can infect all warm-blooded vertebrates, including humans.

Distribution/occurrence

Bovine TB is found worldwide, but is more prevalent in less-developed countries. Efforts are in place for eradication in many developed countries. However, the persistence in wildlife reservoirs makes eradication efforts difficult and success has occurred in only a few countries, including Australia, Denmark, Sweden, Norway, and Finland (Spickler and Roth 2006).

Environmental stability

Mycobacteria do not multiply outside a host except in cultured media. The survivability of *M. bovis* outside of the host depends largely on environmental conditions. Survival time is increased in moist environments, particularly those in which oxygen and organic matter are present. Sunlight, low pH, other microbes, and rising temperatures may decrease survival time (Morris et al. 1994).

In ideal conditions, such as water contaminated with feces and cool, moist, shaded soil, *M. bovis* has been demonstrated to survive from 4 weeks up to 2 years in some reports (Morris et al. 1994). However, with exposure to sunlight or inorganic compounds, survival time is decreased to around 1 week.

2.2 Host

M. bovis has a wide host range and is capable of causing disease in most mammalian species. Cattle and other bovine species are thought to be the primary maintenance hosts. Several wildlife species have been identified as reservoir hosts in many countries. This includes the opossum in New Zealand, badgers in Ireland and Britain, and cervids in the United States (Brown et al. 1994; Corner 2006). Still other species have been identified as spillover hosts, such as humans, coyotes, and cats.

The disease dynamics of *M. bovis* are not well understood despite the long history of disease recognition. The incubation period for bovine TB may last for several months or longer. During the early stages of infection, animals are often asymptomatic, but disease may progress rapidly in some species. Clinical signs may appear with stress or age, and are dependent on the location of lymph node involvement but often include progressive emaciation and weakness. Involvement of the respiratory system results in coughing, dyspnea, or exercise intolerance. Animals with gastrointestinal involvement may have diarrhea or constipation. Enlarged lymph nodes may lead to abscesses.

Transmission of *M. bovis* can occur through various mechanisms depending on the host, route of exposure, and location of the lesions. Aerosolization is thought to be the most infectious route of transmission, accounting for 80 to 90 percent of infections in cattle (Menzies and Neill 2000). A single bacillus in a droplet may be sufficient to establish infection (Morris et al. 1994). Some species, such as opossum, badgers, buffalo, deer, and cattle, excrete bacilli through droplets aerosolized from respiratory infection. These species are able to maintain infection in the population by spreading it to each other through nose-to-nose contact (Corner 2006).

Fecal shedding is likely to occur in spillover hosts, such as ferrets, pigs, cats, and dogs that feed on infected carcasses and acquire infection in the GI tract. Other modes of transmission, such as oral (through bite wounds) and through urine may also occur but are less common (Corner 2006). Vertical transmission has also been documented as an extension of uterine infection of the dam. Offspring and other animals or humans can be infected by bacilli secreted in the milk from mammary infections.

Age, sex, or reproductive status do not appear to have an influence on the direct transmission or susceptibility of an animal to *M. bovis* (Morris et al. 1994). The immune status of humans appears to play a role in susceptibility, but this has not been demonstrated to be the case in cattle.

<u>*Cattle*</u>

Inhalation of aerosolized particles is the primary means for infection transmission to cattle, indicated by the primary lesions commonly seen in the broncho-mediastinal and cranial lymph nodes on necropsy of infected animals. Infection usually takes months to develop. In some instances, the organisms lie dormant within the host's body for its lifetime, without causing progressive disease.

The period of communicability may vary due to stressors or physiologic conditions. Shedding may occur as early as 10 days post-exposure, but typically occurs by day 87 (Neill et al. 1992; Morris et al. 1994). Excretion of bacilli may also occur in animals negative on a tuberculin test (Neill et al. 1992). One study indicated the organism may be recovered as early as 3 days after experimental inoculation from the respiratory tract and associated lymph nodes (Cassidy et al. 1998).

Transmission rates within a herd are difficult to determine and may range from 0 to 40 percent, with lesions identified in 0 to 10 percent of the infected animals (Costello et al. 1998; Spickler and Roth 2006). Typical postmortem lesions include tubercles, or granulomas, where bacteria have congregated. These granulomas are encapsulated and caseous or calcified. Lesions may be found in the lymph nodes, lung, visceral surfaces, or other locations. The size of the lesions in cattle is not an indicator of infectiousness. Animals in the early stages of disease may have no visible lesions but produce substantial amounts of aerosols (Neill et al. 1992; Morris et al. 1994). In experimental infection lesions have been detected as soon as 14 days (Cassidy et al. 1998).

Cervid

The epidemiology of *M. bovis* in farmed and wild cervids is not fully understood. It has been suggested that deer are more susceptible to *M. bovis* infection than cattle (Morris et al. 1994). Host susceptibility and the dose of inoculation also play a role in disease. Deer often develop lesions rapidly and infection appears to spread easily throughout captive herds.

Other domestic species

Small ruminants are susceptible to *M. bovis* infections, but the frequency at which this occurs is much lower in proportion to cattle. The reason for this difference is unknown.

Most infections in swine involve the alimentary tract as a result of ingesting unpasteurized dairy or other potentially infected feed sources. Because fecal secretion is less important than aerosolization, swine are not considered reservoir hosts.

Cats, dogs, and horses have also demonstrated susceptibility to *M. bovis*, but are not thought to play a role in the epidemiology of the disease.

Other wildlife species

Bovine TB has been identified in a number of free-ranging wildlife species including African buffalo, brushtail opossum, badger, bison, and other mammalian species. Wildlife present an epidemiologic challenge for the management of *M. bovis* (De Lisle et al. 2002).

Pathology among wildlife species may vary, depending on susceptibility and route of infection. Antemortem diagnosis is difficult, and while it has a low sensitivity, culture remains the gold standard for detection in wildlife (De Lisle et al. 2002).

Humans

M. bovis poses a health risk to humans, but this risk is minimal in countries that pasteurize milk because the pasteurization process is adequate to kill *M. bovis*. Immunosuppressed patients or individuals exposed to high quantities of tubercle bacilli through aerosolization (abattoir workers or producers) may be at higher risk of infection, even in industrialized countries. *M. tuberculosis* is the primary agent responsible for human TB infections, but *M. bovis* also infects humans, causing zoonotic TB. Infection caused by these two pathogens is clinically indistinguishable in humans.

This risk assessment does not address the risk associated with human exposure to *M. bovis* in Minnesota.

2.3 Detection

Cattle are considered suspect after:

- Positive results from an official field tuberculin test, or
- Findings of suggestive gross lesions at slaughter inspection.

A tentative diagnosis of bovine TB is based on positive results from histopathology (i.e., mycobacteriosis compatible) or positive polymerase chain reaction (PCR) for *Mycobacterium tuberculosis* complex on formalin-fixed tissue.

A confirmatory diagnosis is based on positive isolation and identification of *M. bovis* from the bacteriologic culture of selected tissues.

The official status designation is made by a designated TB epidemiologist.

The official TB tests for live cattle and bison are the:

- Caudal fold tuberculin test (CFT),
- Comparative cervical tuberculin test (CCT),
- Cervical tuberculin test, and
- Bovine interferon gamma assay (cattle only).

The tuberculin skin test is an antemortem test used to detect an immune response to *Mycobacteria* species in humans and animals. About 72 hours after tuberculin is injected, animals are examined for a response at the site of the injection. In animals affected with TB (any strain), a characteristic swelling appears at the point of injection. Animals with a detectable swelling are recorded as responders. A response to this initial screening test (CFT), can be detected as early as 18 weeks post exposure (Waters et al. 2006).

Responders to the CFT must be followed up with an additional test such as the CCT. The CCT consists of injecting bovine PPD tuberculin and avian PPD tuberculin at separate sites in the mid-cervical area to determine the probable presence of bovine TB *(M. bovis),* by comparing the response of the two tuberculins at 72 hours (plus or minus 6 hours) following injection. The responses to the PPD tuberculins are recorded on a scatter plot and are the basis of CCT classification as negative, suspect, or reactor. This test can only be administered by an approved State or Federal veterinarian.

Tuberculosis lesions may be found in any organ or body cavity of diseased animals. In some cases, these lesions are difficult to find, even during postmortem examination. In other cases, the nodules or lumps caused by bovine TB become very evident in the lungs and associated lymph nodes. Involvement of the lymph nodes of the head and intestinal tract is also common. Identification of these lesions is the primary basis of the national TB slaughter surveillance program.

Currently, histopathology, mycobacterial culture, and PCR assay of formalin-fixed tissue are all supplemental diagnostic procedures approved for use in the bovine TB eradication program (USDA:APHIS 2005). These procedures should be used in conjunction with TB test results and necropsy or slaughter data to assign herd status. Culture of the organism can take 4 to 6 weeks but remains the gold standard, despite the low sensitivity, for a confirmatory diagnosis.

The reported sensitivity and specificity of these tests has varied throughout the literature (Norby et al. 2004; Fischer et al. 2005; Meikle et al. 2007). Using these tests in series reduces the sensitivity, but improves the specificity.

Table 1. Types and validity of official TB tests

Family	Test	Sensitivity (%)	Specificity (%)
Bovidae	Caudal Fold (CF)	82	96
	Comparative Cervical (CC)	74	96
Cervidae	Single Cervical	80-85	61-98
	Comparative Cervical	95	95

Source: USDA:APHIS:VS:CEAH 1992.

2.4 Control

Reducing the transmission of bovine TB relies heavily on effective testing mechanisms and reducing exposure to infected animals. Testing and slaughtering of animals with confirmed test results or strong epidemiologic evidence of potential exposure is important to reduce the incidence in cattle populations. Herds potentially exposed to *M. bovis* should be quarantined until test evidence demonstrates a low CFT reactor rate and no suspicious animals on comparative cervical test results. Due to limitations of the tuberculin test in detecting infected animals, depopulation of infected herds of cattle and other species has been the preferred method of eliminating the infection in the United States.

Because of the long survivability of the organism in certain environmental conditions, proper cleaning and disinfection are important to reduce future exposures. *M. bovis* is resistant to many disinfectants, but is susceptible to 5-percent phenol, highly concentrated iodine solutions, gluteraldehyde, and formaldehyde. Long exposure times to 1-percent sodium hypochlorite are effective when organic materials, such as feces, are present (Spickler and Roth 2006).

Section 3: Release Assessment

This release assessment will describe the proposed MA zone and mitigation efforts in place to prevent the release of bovine TB from the proposed MA zone into the rest of Minnesota or other States. This release assessment identifies and describes the biological pathways necessary for the introduction of *M. bovis* from the proposed MA zone into the proposed AF zone. Due to limited information and time, this release assessment does not estimate the likelihood of each event occurring.

3.1 Description of the proposed MA zone

According to the March 11, 2008, Minnesota plan for split-State status (Appendix 5), the proposed MA zone includes a radius of 16.1 km (10.0 mi) around any infected cattle premises and approximately 40.2 km (25.0 mi) around any infected deer as of February 2008. The zone does not extend into the Red Lake Nation to the south. However, two herds (one cattle and one bison) do exist in the Red Lake Nation. There are also numerous free-ranging cervids along the reservation-proposed MA zone border. The boundary of the zone is defined by existing roads to make it easier to identify which cattle premises are included in the zone. The proposed zone contains 300 cattle herds. The production types of all 300 herds have not been defined, but the majority of the herds are cow-calf operations. Nineteen dairy herds are also included in the proposed MA zone.

The zone is comprised of small portions of four counties: Roseau, Marshall, Lake of the Woods, and Beltrami. The topography of the proposed MA zone can be characterized as flat country with poor drainage. Much of the land in the proposed MA zone is woods and pasture. Standard land-use practices within the proposed MA zone are limited by climate and soil type. Cattle grazing and alfalfa production are the two predominant land uses. This land also serves as excellent habitat for deer feeding grounds. Twelve percent of the deer hunted in Minnesota are harvested in the 4 counties in the proposed MA zone, with over 49,000 hunters hunting in the area each year.

The largest component of the agriculture sector in the proposed MA zone is cow/calf production. Thirty-three percent of cow/calf operations in the 4 counties (281 of the 860 farms with beef cows) are located in the proposed MA zone. Twenty-two percent of dairies in the 4 counties (19 of the 85 farms with milk cows) are located in the proposed MA zone. In addition, there are eight farms with goats and one farm with captive cervids in the zone.

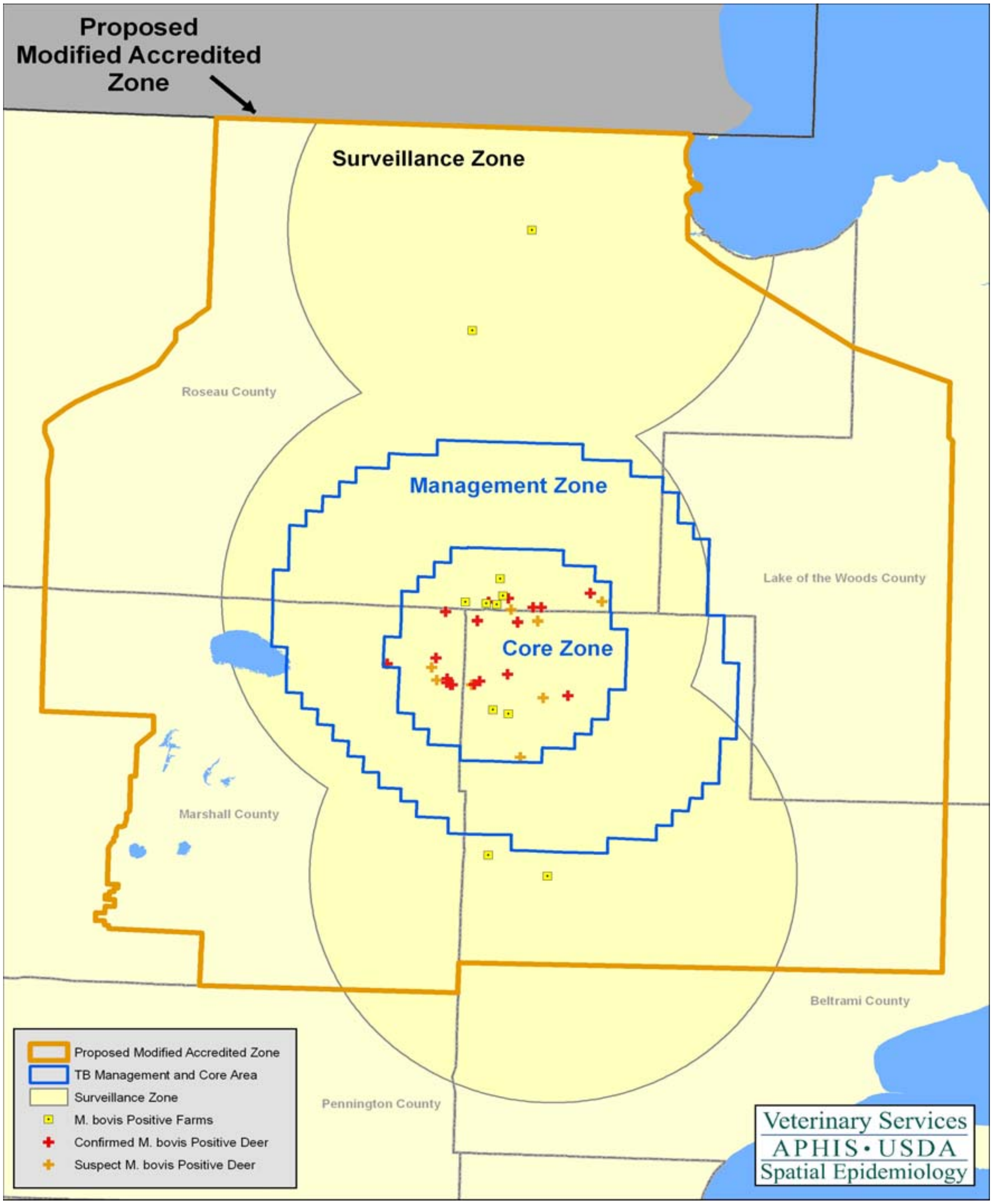

Figure 1. Terminology and demarcation of zones used by Minnesota BAH and DNR from 2005–08.

Within the proposed MA zone, several other zones are demarcated in figure 1 and will be referenced throughout this document. The management area is an area comprised of 56 cattle herds and approximately 3,727 animals. Additional mitigation measures are outlined for these herds in the split-State plan. This area is defined by DNR and BAH in other documents as encompassing an area 16.1 km (10.0 mi) around infected deer based on the 2006 hunting season.

However, findings of additional infected deer during the 2007 season, without changing the borders of the zone, made the buffer shrink to only 11.3 km (7.0 mi).[a]

Within the management area is the core area. This area was also set up based on 2006 infected deer locations, providing a 3.2-km (2.0-mi) buffer around all infected deer. This area has had management practices in place for cattle, but it will no longer be relevant with the implementation of the split-State plan.

The surveillance area outlined in figure 1 is a 16.1-km (10.0-mi) radius surrounding infected cattle premises. Standard practice after detection of an infected herd includes intensive sampling of wild cervids and all cattle herds in a 16.1-km (10.0-mi) area. This zone will be referenced through the document due to the sampling of wild cervids, but does serve a role in the current split-State status plan (Appendix 5).

3.2 Epidemiology of *M. bovis* in the proposed MA zone

Two important questions regarding the epidemiology of *M. bovis* in the proposed MA zone are:

1. How was *M. bovis* introduced into the area?
2. Has the bovine TB outbreak been controlled so that transmission of *M. bovis* to cattle no longer occurs?

Regarding the introduction of *M. bovis* into Minnesota, several hypotheses exist. Based on the results of epidemiologic investigations conducted in Minnesota, this assessment considers the introduction of *M. bovis* from exposure to non-Minnesota cattle that were unknowingly infected. However, this assessment cannot rule out the possibility that *M. bovis* was already present in deer or cattle in Minnesota. In addition, several hypotheses have been discussed to explain the continued spread to Minnesota cattle and wild cervids. This analysis considers all three explanations as possibilities. These include:

1. Infection is spread by local cattle movement and not all cattle movements are recorded;
2. Deer are a reservoir host, serving as a source of infection for both cattle and deer; and
3. An unknown source of *M. bovis* may exist in the area (e.g., hay, contaminated pasture, and contaminated deer feeding ground).

Historical introduction of bovine TB in the proposed MA zone

The following timeline (fig. 2) depicts the approximate date of detection for the 11 infected herds. The herd number (1-11) is based on the order the herds were officially declared infected to USDA.

[a] It is unclear how additional findings of infected deer within or outside the management area will affect this boundary in the future.

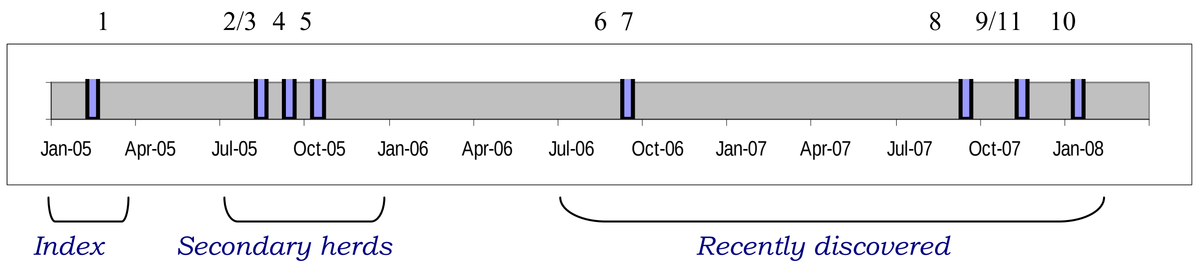

Figure 2. Timeline for the date of discovery for the 11 affected herds.

The index[b] herd was discovered by identification of TB-suspicious lesions in a 5-year-old cull cow at the time of slaughter. The index herd was a large herd of nearly 600 head of Tarentaise and Angus purebreds. Of the 63 CFT responders on the initial whole-herd test (WHT), 6 animals cultured positive, 5 of which were Tarentaise cows of various ages (3 to 10 years old).

Four additional herds that represent secondary herds were discovered when area testing began in fall 2005. These herds were relatively large herds (average 275 head) with a handful of infected animals found in each herd (3 animals on average).

The remaining six infected herds were discovered in October 2006 (two herds) and winter 2007–08 (four herds). Five of these herds had at least one previously negative WHT. These herds were smaller (97 head on average) than the index or secondary herds and typically had only 1 infected animal.

The index herd stands out from the others in herd size, number of *M. bovis*-positive cattle, source of cattle, and breed affected. The majority of animals coming onto the farm were purchased from out of State (90 percent of trace-ins). Two of the six infected animals were from out of State. Also, five of the six infected cattle in the index herd were Tarentaise. Details for the six infected cows on the index farm are shown in table 2. For the other herds, almost all additions were from within the State (97 percent of trace-ins). None of the culture-positive animals were from out of State and the majority of animals were born on the farm. Only 1 of 17 infected cattle from the other 10 herds was a Tarentaise.

Table 2. Summary of infected cattle from the index herd

	Sex	Breed*	Age when necropsied	Approx. DOB	Animal origin
1	F	TR	6	1999	Born on farm
2	F	TR	10	1995	Out-of-State; purchased 11/1999**
3	F	TR	3	2002	Born on farm
4	F	AN	5	1999	Born on farm
5	F	TR	8	1997	Out-of-State;

[b] An index case is the first case in which infection is detected, not necessarily the first infection to occur.

					purchased 1/2000
6	F	TR	5	2000	Born on farm

*AN = Angus; TR = Tarentaise.
**Likely moved January 2000.

One possible scenario is that bovine TB was in Minnesota before the index herd was found, but not detected until 2005. The primary surveillance program in place for detection of bovine TB, prior to detection of the index case, was slaughter surveillance. The sensitivity of slaughter inspection is very poor, reported by Ducrot et al. (1997) to be 50 percent. In 1999–2000 suspicious granuloma submissions were at the lowest point in the last 25 years (Kaneene et al. 2006). The median time to detect bovine TB via visual inspection of carcasses at slaughter is estimated to be 300 weeks (5.75 years) (van Roermund et al. 2003; Fischer et al. 2005). The 5 years to detection is consistent with expectations found in the literature and may indicate bovine TB was present in Minnesota prior to the identification of the index herd. This could be through the introduction of a non-Minnesota animal into the index herd or a low prevalence of *M. bovis* already present in Minnesota cattle or deer.

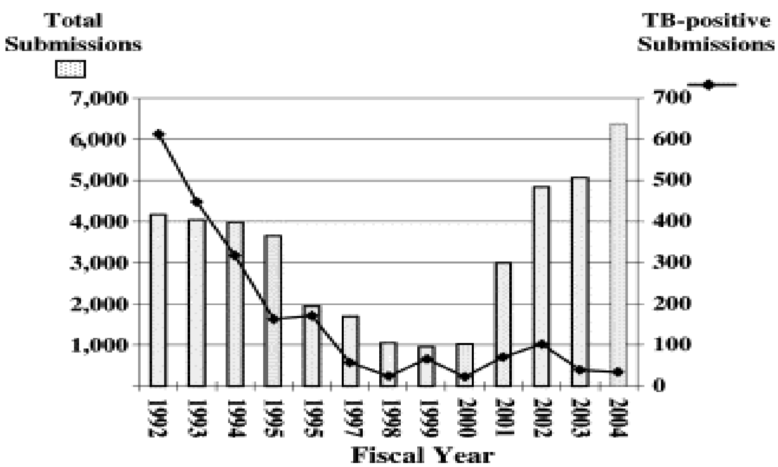

Figure 3. Granuloma submissions for slaughter surveillance (Kaneene et al. 2006).

<u>*Explanation for recently discovered infection in cattle and deer*</u>

The recent discovery of six infected herds since October 2006 (table 17) poses two important questions for consideration:

1. Do these herds represent secondary spread from the index herd that was not detected in the first year of the outbreak or with annual herd testing?
2. Do they represent new infections from other sources?

In other words, has the bovine TB outbreak been contained and the delay in detecting the six additional infected herds due to poor sensitivity of testing and/or low levels of surveillance, or is active transmission of *M. bovis* still occurring in northwest Minnesota?

The approach taken in the attempt to answer this critical question was to examine four areas that may provide evidence of recent transmission or previously undetected transmission:

1. Epidemiological analysis of these herds for evidence that might suggest recent infection.
2. Evaluation of epidemiological links to the index herd. If control measures put in place after discovery of the index herd and the four secondary herds were effective at shutting down active bovine TB transmission, then the recently discovered herds must have been infected at the same time as the other secondary herds. In that case, there should be an epidemiological link to the index herd.
3. Evaluation of the expected number of false negatives to assess the probability that these herds were infected in 2005 but missed by surveillance activities in the proposed MA zone. Given that a number of herds were subject to a whole-herd test (WHT) in that first year after discovering the index herd, how many herds could have been missed given the poor sensitivity of the test? If the six recently discovered herds is a reasonable number of false-negative herds to expect, then this would be consistent with the belief that bovine TB has been contained. However, if this is significantly more than expected, then the recently discovered infected herds are more consistent with the belief that the bovine TB outbreak is not contained.
4. Assessment of the prevalence of *M. bovis* in deer in the proposed MA zone. Of particular concern is whether or not these herds were recently infected via exposure to deer, a sign that bovine TB has become established in the deer population of northwestern Minnesota.

1. Epidemiological analysis of the recently discovered infected herds: As described above, the recently discovered infected herds differ from the other infected herds in several ways. They were smaller on average and had fewer positive animals. Five of the six herds had only one positive animal and the sixth herd had two positive animals. In comparison, the index herd had six positive animals and the secondary herds have three each, except for herd 3 which had only one.

One explanation for finding fewer positive animals in the secondary herds than in the index herd is the shorter time to detection. More time between exposure and discovery provides more opportunity for bovine TB to spread within the herd. The time to detect the index herd was approximately 5 years because it was based solely on slaughter inspection. The secondary herds were infected from 2002–04 for herds 2, 3, and 4. For infected herd 5, infection could have occurred anytime between spring 2000 and fall 2005. Therefore, the average time until detection, in fall 2005, was roughly 2.5 years. This is approximately half the time for bovine TB spread in comparison to the index herd, if the explanation described above is true.

For herds 6, 7, and 8 the positive animals were less than 2 years old and the average time to detection was only 1.5 years. For herds 9, 10, and 11, the positive animals were over 3 years of age and the herd could have been infected anytime after the index herd was, about 3 years on average. However, if it is assumed herds were infected after the most recent negative WHT, then time to detection would be only a little over 1 year.

Therefore, the low number of positive animals found in the recently discovered herds suggests that these herds were recently infected.

Table 3. Dates TB was likely transmitted to each infected herd and proposed source of infection based on a review of the documents provided by Minnesota

Infected herd	Period positive animal was infected: Earliest	Latest	Link to index	Possible sources of infection
1	Jan 2000[1]			Out of State[6] cows purchased at 3 & 5 years old
1	Jan 2000[2]	Jan 2005		Index animals in herd
2	Summer 2002	Fall 2005	Yes–Adjacent	
3	Spring 2004	Fall 2005	Yes–Adjacent	Fenceline contact; deer exposure
4	Spring 2002[3]	Fall 2005	Yes–Traced out	Three calves purchased; possibly infected first year of life in herd 1
5	Spring 2000	Fall 2005	No	Purchased young stock from herds 1, 2, or 3 via market[4]
5	May 2005	Fall 2005	No	Infected cow in herd
6	Feb 2005	Sep 2006	Yes–Adjacent[5]	Deer exposure; fence-line contact
7	Feb 2005	Sep 2006	No[5]	Deer exposure
8	Spring 2006	Sep 2007	No	Deer exposure
9	Spring 2003	Dec 2007	No	
10	Spring 2000	Jan 2008	Yes	Area spread via deer or direct contact with herd 2 or 3 cattle
11	Spring 2000	Dec 2007	No	

[1]Index animals brought from out of State.
[2]Two were calves and a yearling at time index animals entered the herd in Jan 2000.
[3]Born on herd 1 in Spring 2002, most likely infected there before being sold Feb 2003.
[4]This herd had more traces into it than all other herds combined—159 from MN.
[5]Infected animals were born Spring 2005 and index herd quarantined in July 2005. Given this short window, it is just as likely (if not more) that the animal was exposed to deer as a young animal—especially for herd 7 which was not adjacent to index herd like herd 6 with was.
[6] All successful out of State traces were negative at the time of this assessment
→ In constructing this table the number of positive animals was minimized in explaining possible routes of transmission; i.e., where possible it was assumed that the known positive animals were the only positive animals in the herd and there were no undisclosed positive animals.

2. Epidemiological link to the index herd: An epidemiological link between the recently discovered herds and the index herd would provide evidence that transmission of TB occurred prior to fall 2005 and that the prior negative WHTs were false negatives due to the low sensitivity of the CFT. Spoligotyping indicates that the same strain of *M. bovis* is found in all infected animals discovered in Minnesota.

Infected herds 2, 3, and 4 all were epidemiologically linked to the index herd. Two were adjacent and one purchased three yearlings in February 2003. The fifth infected herd did not have a clear epidemiological link to the index herd.

Only two of the recently discovered herds had an epidemiological link to the index herd but in both cases it was somewhat weak. Although herd 6 was adjacent to the index herd, the positive animal was born in February 2005, providing a short window for direct contact (fence-line) exposure to the index herd before it was quarantined in July 2005. The WHT in September 2005 was negative so it is possible that exposure occurred sometime after summer 2005, in which case it would not be epidemiologically linked to the index herd. Herd 10 had direct fence-line contact with herd 2 and so does not really have a direct epidemiologic link to the index herd. The herd could have been exposed to positive animals in herd 2 (e.g., the positive bull), contaminated feed, or infected deer in the area. An infected deer was harvested in fall 2006 0.8 km (0.5 mi) from herd 10.

Therefore the lack of an epidemiological link between the recently infected herds and the index herd casts doubt that these herds were infected during the same time period as the other secondary herds but went undetected. Furthermore, an epidemiological link to deer exists for several of these herds. In addition, herds 6, 9 (summer pasture), and 10 were within 3.2 km (2.0 mi) of known positive deer.

3. Expected number of false-negative herds: A striking feature of the six recently discovered herds is that five of them had a negative WHT prior to detecting a positive animal. (See table 17 for a list of all WHT for the recently discovered herds.) Two of the more recent ones (herds 9 and 10) had two annual WHTs that were negative prior to discovery in winter 2007–08. As already noted, these herds were much smaller on average than the index and secondary herds. The 2 largest herds had approximately 200 adult cows and the other 4 all had fewer than 40 head.

At face value, the prior negative WHTs would indicate the herds were truly negative. However, applying a screening test of low sensitivity for a low prevalence disease in small herds increases the risk of obtaining false-negative results. The probability of correctly identifying a positive herd (herd sensitivity [Se]) is dependent on the test sensitivity, within-herd prevalence, and the cutoff value for number of expected positive tests needed to classify the herd as suspect.

To illustrate the effect of herd size, table 4 shows the estimated herd sensitivity for the average size of the index herd (600), the secondary herds (300 and 150) and the recently discovered herds (150 and 50). The intent of the table is to illustrate the increased likelihood of missing small herds and not to estimate the herd Se parameter.

Table 4. Effect of herd size on herd sensitivity

Herd size	Cut-off	Herd Se (%)
600	10	100
300	10	99.3
150	6	91.9
50	2	83.4

To better estimate the expected number of false-negative herds from the WHTs conducted in 2005, a model was constructed using @Risk (@RISK 2004), a risk analysis software program, to assess the probability of false negative herds—whether or not the six recently discovered herds were infected along with the secondary herds but not detected until later due to false-negative results. The model was constructed to simulate the expected number of false-negative herds given the situation in 2005. The specific inputs for the model are presented table 5.

Table 5. Inputs for @Risk model to simulate expected number of false negative herds

Input parameter	Value	Comment
N (population at risk)	150	Number of herds tested the first year after finding index herd
Herd size	Random draw from herd size distribution	Based on number animals tested for WHT conducted in MA zone
Herd prevalence	Random draw from a pert distribution (0, 4, 5) over N	Pert distribution is min, most likely, max number of infected herds
Within-herd prevalence	3%	Based on actual within-herd prevalence in first 10 infected herds

Given a sensitivity of 0.82 and specificity of 0.96 for the CFT, the mean number of false-negative herds was 1.3 herds (for 5,000 iterations). The six herds discovered since the initial case-finding activities is more than twice the number of expected false-negative herds. The 95-percent confidence interval was 0 to 4 herds. Therefore, less than 5 percent of the time would it be expected to have missed six herds via a WHT. The implication is that the recently discovered herds likely represent recent bovine TB transmission and not missed infection.

Certainly, the effectiveness of surveillance activities in finding existing cases is influenced by more factors than just the probability of detection based on test performance (e.g., sampling design, trace-out ability, etc). However, the scope of the project prohibited a more in-depth evaluation of case-finding surveillance activities.

4. Role of deer in the epidemiology of bovine TB in the proposed MA zone: After the identification of the index *M. bovis*-positive cattle herd, the Minnesota DNR conducted surveillance of hunter-harvested white-tailed deer within a 24.1 km (15 mi) radius of the first four *M. bovis*-infected premises. Results were that 1 of the 474 deer tested positive for *M. bovis.* The infected deer was harvested 1.9 km (1.2 mi) south of the index herd, and less than 5.0 km (3.1 mi) from the other initially infected cattle herds. This prompted targeted culling and surveillance of 90 deer during spring 2006 through landowner shooting permits on the infected farms, resulting in the finding of 1 additional positive deer.

The infected deer appeared to be associated with *M. bovis*-infected cattle herds in the region, based on proximity and because they share the same strain of bovine TB as the cattle, as determined by spoligotyping. As a result, the DNR instituted more rigorous sampling protocols to establish prevalence of *M. bovis* in the deer population. An estimated fall pre-hunt population of 15,000 deer over 18 months of age inhabits the 4,475 sq km (1,728 sq mi) surveillance zone (fig. 1). A sampling goal of 1,000 samples was determined to provide the number of samples necessary to ensure 95-percent confidence of detecting *M. bovis* if prevalence in the deer population is >1 percent.

Currently the DNR conducts hunter-harvested deer surveillance during the fall hunting season. If *M. bovis*-infected deer are identified, targeted culling is conducted in the spring around areas where infected deer have been found. This culling includes using sharpshooters, baiting, land owner shooting permits, and most recently, the use of aerial gunning. To date the DNR has tested 4,043 deer in the surveillance zone and has identified 18 positive deer and an additional 8 suspect deer (1 of which is a juvenile female) that are awaiting confirmation (table 6).

Table 6. Total number of white-tailed deer sampled for *M. bovis*

	Fall		Spring		Total	
	N	Positive	N	Positive	N	Positive
2005	474	1	-	-	474	1
2006	942	5	90	1	1,032	6
2007	1,166	5	488	6	1,654	11
2008	-	-	883[1]	8[2]	883[1]	8[2]
Total	**2,582**	**11**	**1,461**	**15**	**4,043**	**26**

[1]Spring culling is still in progress.
[2]Presumed positives awaiting confirmation.

As of April 15, 2008, 1,719 deer have been culled from the core zone and an additional 1,019 deer have been culled from the TB management zone. An area of 10.4 sq km (4.0 sq mi) adjacent to the index herd alone has had 181 deer culled. The estimated deer population in the core area was 923 (±150) in February 2007 and 803 (±133) in January 2008. The current harvest far exceeds the estimated population, which may be the result of movement of deer into the core zone as a result of newly available habitat, a larger original population than initially estimated, and/or a high reproduction rate for deer in the region.

Of the *M. bovis*-positive deer, only two identified in 2007 were considered juvenile deer (1.5 years old) and would have been born in 2005. However, one juvenile female deer sampled in spring 2008 is currently awaiting confirmation and would have been born in 2006, indicating a recent exposure. The remaining confirmed positive deer were 2.5 years and older. Of the positive deer, five of these deer were older than 4.5 years of age. As of June 6, 2008, confirmation is pending on an additional eight suspect deer sampled during spring 2008. These deer range in age from 1.5 to 7.5 years. These results are consistent with sampling that has been conducted in Michigan where adult deer, specifically males, were found more likely to be infected with *M. bovis*. To date no fawns have been found to be infected with *M. bovis*. The majority of deer tested within the surveillance zone (62 percent) have been adult deer. Currently sampling tested equal proportions of male and female deer (table 7).

Table 7. Age and sex of deer sampled during the fall hunter surveillance within the proposed MA zone (2005–2007)

	Sampled Deer[1]			Positive Deer	
	N	%	Cum %[2]	N	%
Females					
Unknown	25	1.7	0.8	-	-
Fawn	101	6.9	3.4	-	-
Juvenile	278	19.0	9.3	1	0.36
Adult	1,062	72.4	35.4	6	0.56
Total	1,466	100.0	48.9	7	0.48
Male					
Unknown	28	1.8	0.9	-	-
Fawn	103	6.7	3.4	-	-
Juvenile	591	38.6	19.7	1	0.17
Adult	810	52.9	27.0	5	0.62
Total	1,532	100.0	51.1	7	0.46
All Deer					
Unknown	53	1.8	-	-	-
Fawn	204	6.8	-	-	-
Juvenile	869	29.0	-	2	0.23
Adult	1,872	62.4	-	11	0.59
Total	2,998	100.0	-	14	0.47

[1]Includes 11 positive deer identified during hunter surveillance and 10 deer identified during spring culls.
[2]Percentage of animals tested by age and sex category.

Based on fall hunter-harvested sampling, the average estimated apparent prevalence between 2005 and 2007 in white-tailed deer in the proposed MA zone is 0.43 percent, which is similar to the overall apparent prevalence of 0.54 percent reported for Michigan white-tailed deer (O'Brien et al. 2002). However, apparent prevalence in fall hunter-harvested deer appears to be higher in both the management zone (0.71 percent) and the established core zone (1.97 percent) (table 8) compared to the rest of the proposed MA Zone. These apparent prevalence estimates are lower than those reported in Michigan's core zone, which ranged from 1.2 to 4.9 percent (Michigan DNR 2008).

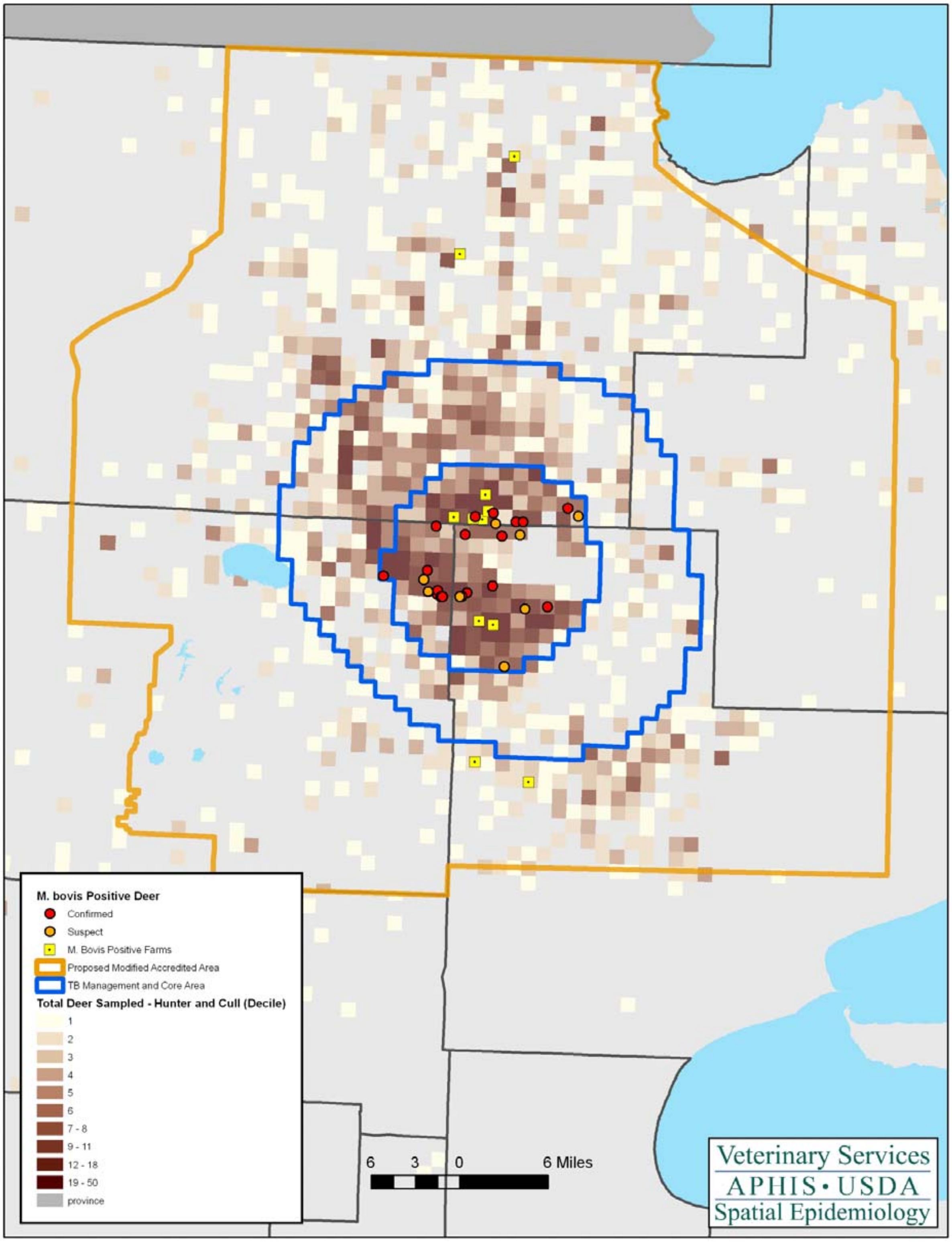

Figure 4. Culling and sampling of white-tailed deer as of April 15, 2008.

Current sampling is designed to ensure 95-percent confidence of detecting the *M. bovis* if prevalence in the deer population is >1 percent. Currently the overall estimated apparent prevalence in deer is <1 percent. In order to effectively detect disease in the area of the proposed MA zone outside the management area, the sample size will likely need to be increased to reach the goal of 95-percent confidence of detecting *M. bovis*. This is currently being attempted through liberalization of hunting seasons, aerial gunning, and other tools within the core zone. However, additional sampling is needed to estimate the apparent prevalence in the entire proposed MA zone.

Table 8. Estimated fall prevalence of *M. bovis* in white-tailed deer

			Estimated fall prevalence					
Year	**Total sampled**		**Core area**[1]		**Management area**[2]		**MA zone**[3]	
	N	**Positive**	**%**	**N**	**%**	**N**	**%**	**N**
2007	1,166	5	1.63	245	0.57	702	0.45	1,121
2006	942	5	2.60	192	1.05	478	0.53	942
2005	474	1	1.43	70	0.45	221	0.22	463
Overall	**2,582**	**11**	**1.97**	**507**	**0.71**	**1,401**	**0.43**	**2,582**

[1]Includes only deer sampled from the core area.
[2]Includes only deer sampled from the core area and the management zone.
[3]Includes all samples collected within the proposed MA zone.

The results of this sampling indicate some degree of clustering of *M. bovis*-positive deer. Clustering was tested using Moran's I statistic. Moran's I is a measure of global spatial autocorrelation, which is a measure determining if adjacent observations of the same phenomenon are correlated. The statistic evaluates both location of events (proximity) and values simultaneously. In general, a Moran's Index value near +1.0 indicates clustering, while an index value near -1.0 indicates dispersion. The Moran's Index for the deer data was 0.0043 with a strongly significant Z-Score of 9.63[c] indicating some degree of clustering of positive deer locations. In addition, the results of the statistic do not change over the 3 years of sampling, which may indicate a source of environmental exposure, site fidelity of infected deer, or some other mechanism that cannot be identified.

In addition, deer appear to be spatially associated with known infected cattle herds. The average distance between infected cattle herds and *M. bovis*-positive deer in the TB management area is 7.9 km (4.9 mi) (StDev=3.6 km (2.2 mi); Min=0.3 km (0.2 mi)). Furthermore, 61 percent (11 out of 18) of positive deer and 63 percent (5 out of 8) of suspect deer are within 5.0 km (3.1 mi) of infected cattle farms. All positive and suspect deer are within 10.9 km (6.8 mi) of *M bovis*-infected farms. Further analysis, such as Kuldorf's Scan Statistic, could be conducted to

[c] A Z-Score is a standard score that is a dimensionless quantity derived by subtracting the population mean from an individual raw score and then dividing the difference by the population standard deviation. Z-score values for the 0.05 level of significance are ±1.64 and for the 0.01 level of significance are ±2.33.

determine if there is a spatial association between *M. bovis*-infected deer locations and *M. bovis*-infected cattle herds.

With these analyses, it is not possible to determine if cattle or deer play the primary role in disease transmission; however, there does appear to be a spatial association between *M. bovis*-infected cattle herds and white-tailed deer. Few studies are available that quantitatively estimate the direct and indirect contact rates between deer and cattle. One study focusing on dairy cattle in central Minnesota found that cattle on 20 percent of farms had indirect contact with deer via feces on a daily basis, and cattle on 40 percent of farms had indirect contact via feces more than once a month (Raizman et al. 2005). Currently APHIS:WS is using GPS tracking collars to collect data from white-tailed deer in Michigan. The goals of the research are to estimate contact rates between cattle and deer and to determine daily and seasonal differences in rates of contact between the two species. The results of these analyses may better explain the potential contact between white-tailed deer and cattle.

Summary of current status of cattle and deer in the proposed MA zone

This assessment assumes the initial source of infection of bovine TB in Minnesota to be from the introduction of infected cattle; however, this cannot be conclusively determined. Four specific analytical elements were assessed in order to obtain evidence that the most recently infected herds were either a failure of detection during epidemiological investigations or a signal that active bovine TB transmission continues to occur in the proposed MA zone.

Based on the four elements analyzed for this rapid assessment, the conclusion is that active transmission of bovine TB continues to occur in the proposed MA zone.

3.3 Mitigation efforts proposed by the Minnesota split-State plan[d]

As a part of Minnesota's proposed plan, all bovine, bison, or cervid producers inside the proposed MA zone are required to provide farm location information to the BAH. Official identification is required for all cattle leaving the zone. All 300 herds in the zone would require annual herd testing of animals over 12 months of age. All cattle moved into or within the zone must be officially identified and be accompanied by an Intrastate Movement Certificate showing the origin and destination of the animals, including cattle brought into the zone for grazing.

All cattle moved out of the zone must be officially identified and accompanied by an Intrastate Movement Certificate, which includes a State-issued permit number or is signed by an authorized agent of the BAH, and which shows the origin and destination of the animals. For animals moved out of the zone to another State, the movement certificate shall be replaced by a Certificate of Veterinary Inspection.

Within the proposed MA zone, the TB management area would have additional management requirements for reducing the deer/cattle interaction. These additional requirements include:

[d] It was assumed that these mitigation efforts meet, at minimum, all USDA outlined requirements for MA states or zones. The specific wording used in this section is taken from MN split-State Plan (March 11, 2008). Minnesota is currently reviewing this terminology and guidelines to be more consistent with CFR and UM&R terminology.

- Opportunity for buyout or an annual risk assessment with required implementation of recommendations,
- Deer-proof fencing around the stored feed,
- Annual herd inventory, and
- 5-year maintenance of all business records.

A recent bill passed by the State of Minnesota (Olin et al. 2008) outlines the plan for a cattle herd buyout of the 56 herds within the management area. Owners accepting the buyout would receive an annual allowance and sign an agreement that no animals will be housed on their property until permission is granted by the BAH. Owners who accept the buyout but do not follow the agreement will be fined and required to repay the amount of the buyout.

Owners not accepting the buyout will receive a risk assessment of their property to evaluate the potential for deer/cattle interactions. Recommendations will be made to minimize the potential deer/cattle interactions based on this risk assessment and owners are obligated to follow these recommendations. Minnesota will provide State funding to help owners construct fences to minimize deer contact with cattle or cattle feed.

At this time it is unknown how many owners will elect to accept the buyout. Therefore, the effect that this buyout would have on the spread of bovine TB within the zone cannot be estimated at this time. It is unclear how this buyout will help reduce the presence of *M. bovis* in the environment over time, which is necessary for achieving AF status in the future. In order to reduce the presence of *M. bovis* in the environment, other foci for bacterial maintenance must be considered. Additional research is needed to determine the roles of deer-feeding areas, stored hay, and other potential wildlife reservoirs in the area.

The following description of pathways for the spread of *M. bovis* outside the proposed MA zone will help assess the effectiveness of these mitigation efforts.

3.4 Pathways for the spread of *M. bovis* out of the proposed MA zone

Pathway 1: Cattle movement

Cattle movements serve as significant predictors of bovine TB distribution, and therefore are significant risk factors in *M. bovis* transmission. In Great Britain, of the *M. bovis* infections that occurred in cattle during the 2004 outbreak, 16 percent were outside the high-risk zones and could be attributed to cattle movements. The majority of infections (75 percent) were inside the defined high-risk zone and could be attributed to local effects (Phillips et al. 2003; Green et al. 2008).

In Minnesota, 11 infected herds have been identified in the proposed MA zone since January 2005. Based on the epidemiological findings from these 11 herds, direct contact may have served as a source of infection in some instances. The most common movement out of the 11 affected herds was the selling of feeder calves and cull cows and bulls (Minnesota Board of Animal Health 2008). Feeder calves are sold in fall or winter at local sale barns. Trace-out investigations from these herds to herds outside the proposed MA zone have discovered no additional infections. However, at the time of these assessments, trace-out investigations for the most recently infected herds were not complete. It is unknown how many traces were successful, but the success rate is thought to be low based on the data provided.

All of the 11 infected herds have been depopulated as of March 28, 2008. On average, a time frame of approximately 2 months was required to depopulate a herd after it was officially declared positive; however, with one herd, depopulation took 5 months to complete. At least five owners of those depopulated herds have repopulated their premises with new cattle.

Despite low estimated within-herd prevalence (3 percent), historical and future animal movements may serve as risk factors for *M. bovis* spread outside the proposed MA zone. Previous analyses (section 3.2) demonstrate the possibility of a current source of infection persisting inside the proposed MA zone. The following analysis will evaluate animal movement patterns from the proposed MA zone to determine where contact events are/were most likely to occur. This movement analysis will illustrate historical areas of risk where surveillance efforts are needed to determine if *M. bovis* is already established in the proposed AF zone.

In addition, the likelihood of a shipment containing an infected animal is also explored, to determine if future surveillance is needed in the proposed AF zone or if current proposed mitigation efforts are enough to contain bovine TB.

Cattle Movement Patterns: Trace data from the epidemiological investigations of the 11 infected herds[e] were used to identify areas and producers (in the proposed AF zone) that may have a higher connectivity in terms of animal movement and, in turn, a higher risk for either past or future exposure to *M. bovis*. It is assumed that trace data represent, on average, the typical movement dynamics of cattle producers for the proposed MA zone.[f]

In order to best determine exposure of *M. bovis* to producers, trace premises were classified into categories that included producers, dealers, markets, and breeding herds. State and Federal veterinary medical officers were asked to classify all the premises that were identified as receiving a trace. Analysis was restricted to premises that were likely to maintain cattle on-site (producers and breeding herds) and did not represent animals in the slaughter channel, going through markets, or other movement where exposure to other animals was unlikely. If no information on the premises was provided, the most conservative estimate was used and the premises was assumed to be a cattle producer.

This represented a total of 526 trace events (trace-in and trace-out) representing 4,660 animals. Trace-out events represented 222 movements and 3,081 animals. The average shipment size for primary trace-out events was 6 animals (StDev 11), but ranged from 1 to 110. Shipment size for primary trace in events averaged 5 animals (StDev 7) and ranged from 1 to 70 animals. However, shipment size varied greatly based on the destination or source of the shipment. These data were stratified into two subsets: (1) all trace events (both in and out), and (2) only trace-out events. This was done to estimate animal movement both in and out of the region and to identify areas

[e] Not all investigations were completed at the time of this analysis.
[f] This assessment was not able to look at dairy cattle movements from the MA zone because these data were not available.

with the greatest risk for historic exposure and future exposure to animals from the proposed MA zone.

The distance between trace premises was measured and minimum convex polygons (convex hulls) were calculated for trace events representing 25, 50, 75, 90, and 95 percent of trace events. Minimum convex polygons are an accepted method for representing movement events (Burgman and Fox 2002). Other methods of representing movement events are available, such as harmonic mean and various kernel estimators; however, given the time limitations, all options for describing movement were not explored. These differing methods can provide, in some cases, large differences in results and should be explored in future analysis (Lawson et al. 1997). This analysis was conducted for both subsets of data and is presented in figure 5.

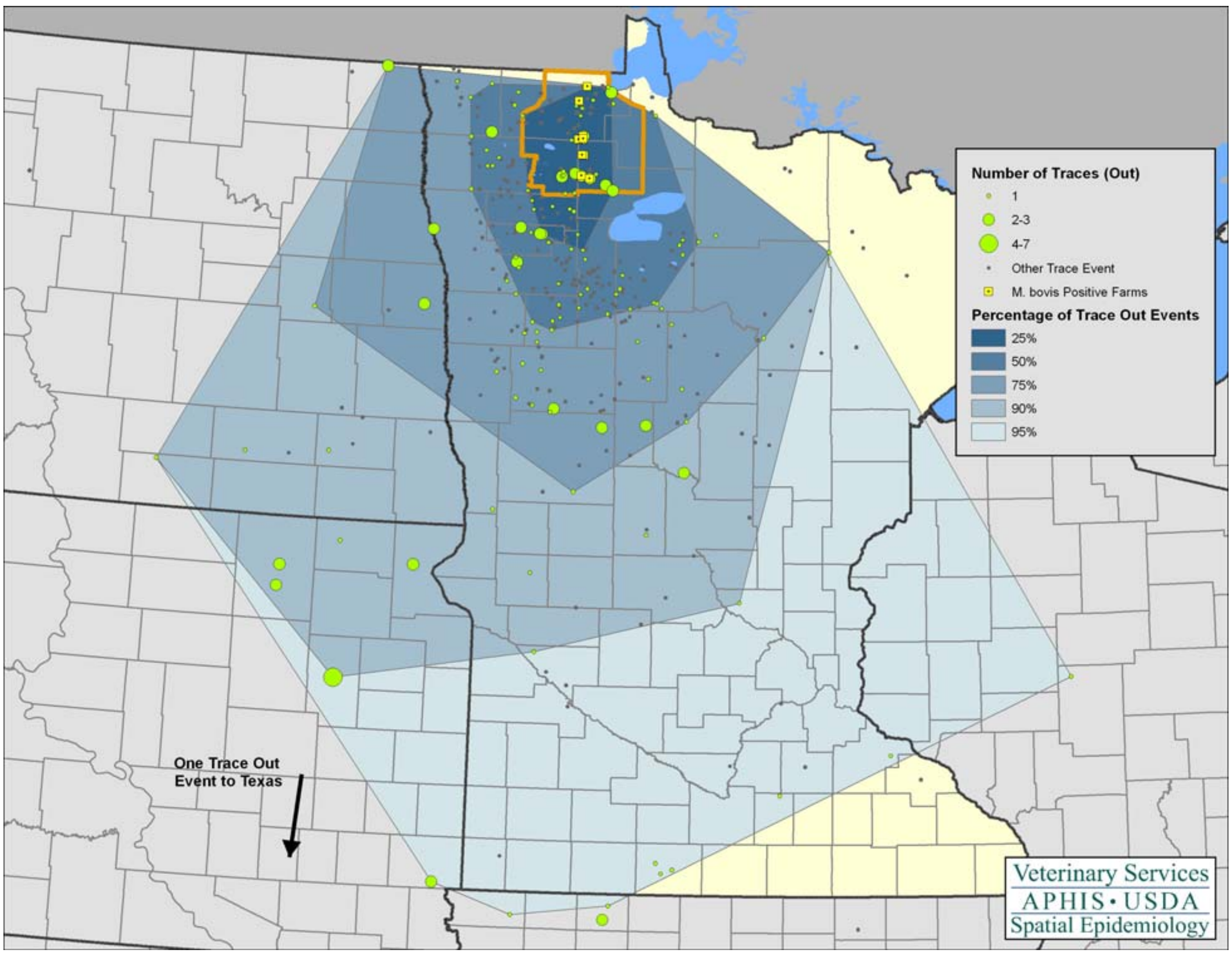

Figure 5a. Minimum convex polygons for cattle movement events—trace-out events.

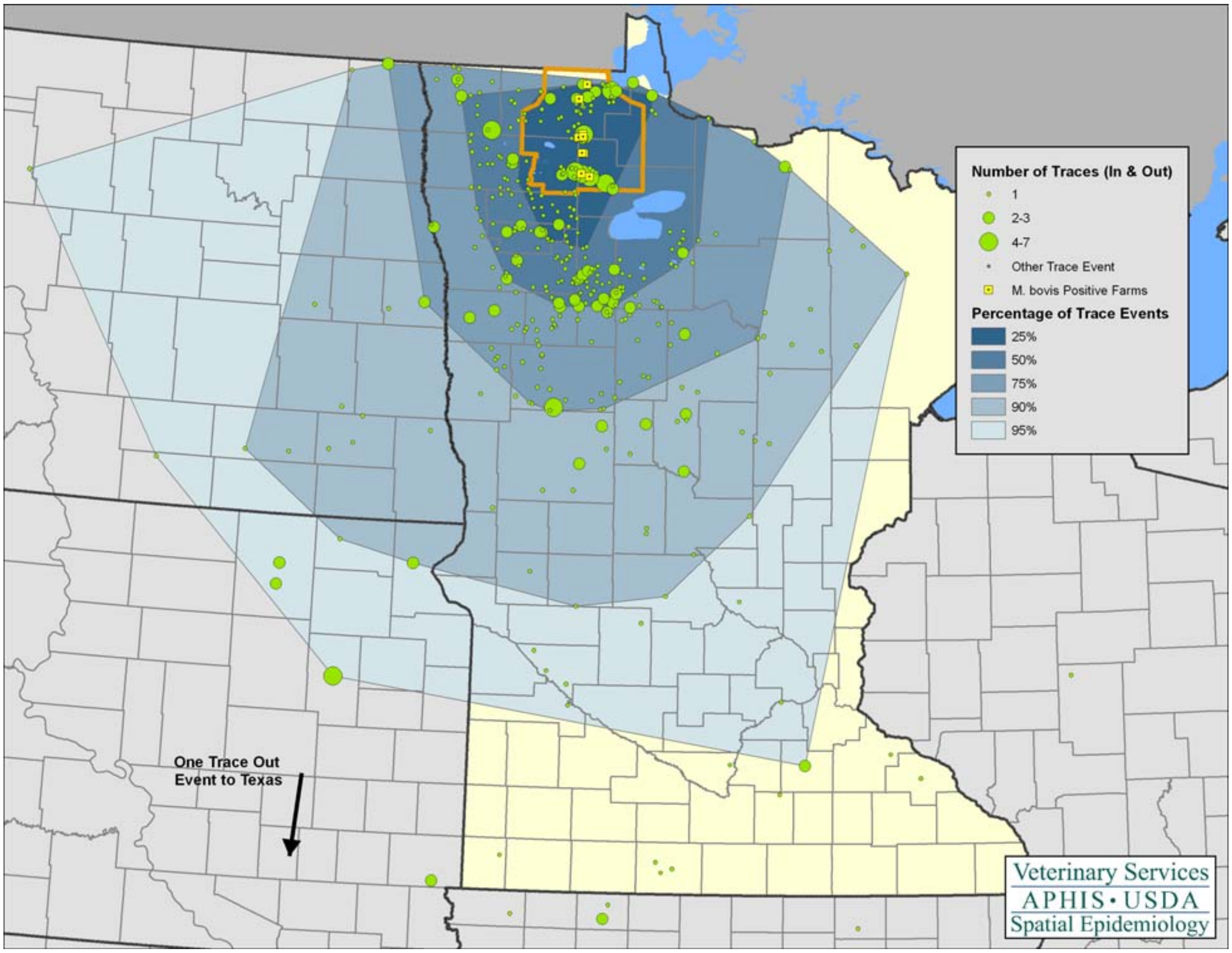

Figure 5b. Minimum convex polygons for cattle movement events—all trace events.

The proposed MA zone accounts for 17.5 percent (92) of movement events[g] into or out of the proposed MA zone and 12.5 percent (581) of total animals moved. When analysis was restricted only to movements out of the proposed MA zone, 17.9 percent of the movement events and 8.5 percent of the animals were represented. This is illustrated by the minimum convex polygons in figure 5. If the 50th percentile of movement represented by minimum convex polygons of movements out of the zone is used, 23.3 percent (719) of animals moving out of the zone are captured and 36.2 percent (1,688) of the total animal movement is captured (table 9).

Table 9. Comparison of number of movements and number of animals represented by the proposed MA zone and minimum convex polygons

	Out movements		Total movements	
	Movements	**Animals**	**Movements**	**Animals**
Proposed MA zone	17.6% (39)	8.5% (262)	17.5% (92)	12.5% (581)

[g] One movement event represents one shipment of animals.

50% minimum convex polygon of out movements	49.5% (110)	23.3% (719)	53.2% (280)	36.2% (1,688)
Total movements	**222**	**3,081**	**526**	**4,660**

In addition to minimum convex polygons, the Getis-Ord Gi* statistic was used to identify statistically significant clusters that represent areas with higher than expected movements of animals out of the proposed MA zone. The Getis-Ord Gi* statistic is one of many statistics that measures spatial autocorrelation and pattern in spatial data and should be considered a preliminary analysis tool (Lawson and Denison 2002). The Gi* statistic indicates whether events—in this case movement events—with high values or low values tend to cluster. This statistic compares each feature within the context of neighboring movement events. If a movement event value is high (number of animals or number of traces), and the values for all neighboring features is also high, it is identified as a cluster. The local sum for a feature and its neighbors is compared proportionally to the sum of all trace events; when the local sum is much different from the expected local sum, and that difference is too large to be the result of random chance, a statistically significant Z score is the result.

This analysis was conducted for both the number of animals associated with each movement and for the total number of movements. Figure 6 represents the results of the analysis. The analysis indicates a high degree of clustering of movements for the entire northwest portion of Minnesota at the 95-percent level of confidence when measured by the number of animals moving between producers. The highest Z scores occurred outside the proposed MA zone in the Karlstad/Newfolden/Middle River area. An additional cluster was also identified in the southwest corner of Minnesota, indicating that, in terms of the number of animals moving, there appear to be significant clusters of movement between the proposed MA zone and southern Minnesota. However, when only the number of movement events was used in the analysis, a smaller cluster was identified in the northwest region of Minnesota. The highest Z scores occurred in the Grygla and McIntosh/Fosston regions. The number of animals moving between herds may be the best indicator of risk because this method of analysis may most accurately indicate the potential degree of exposure. However, further analysis would be required to better understand and fully estimate the risk.

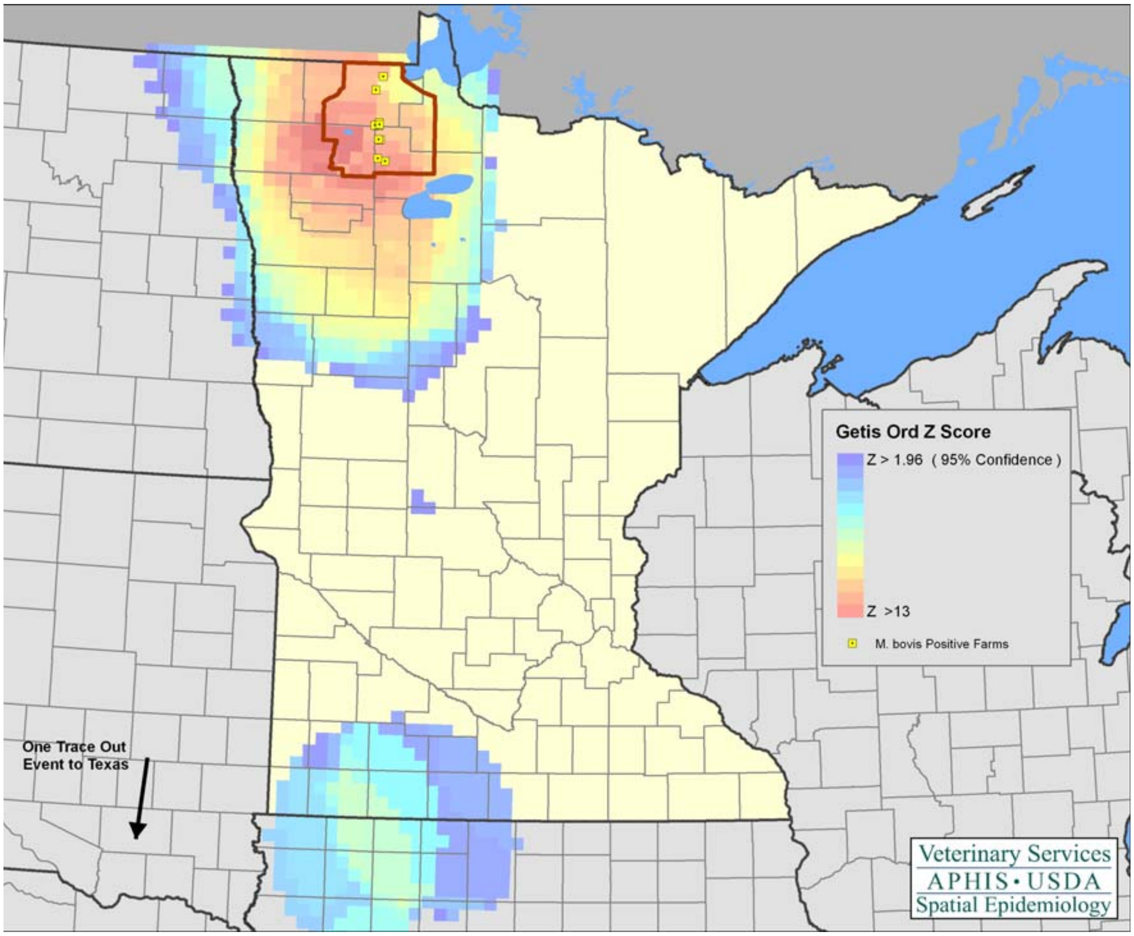

Figure 6a. Getis-Ord GI* clusters of movements out of the proposed MA zone—number of animals.

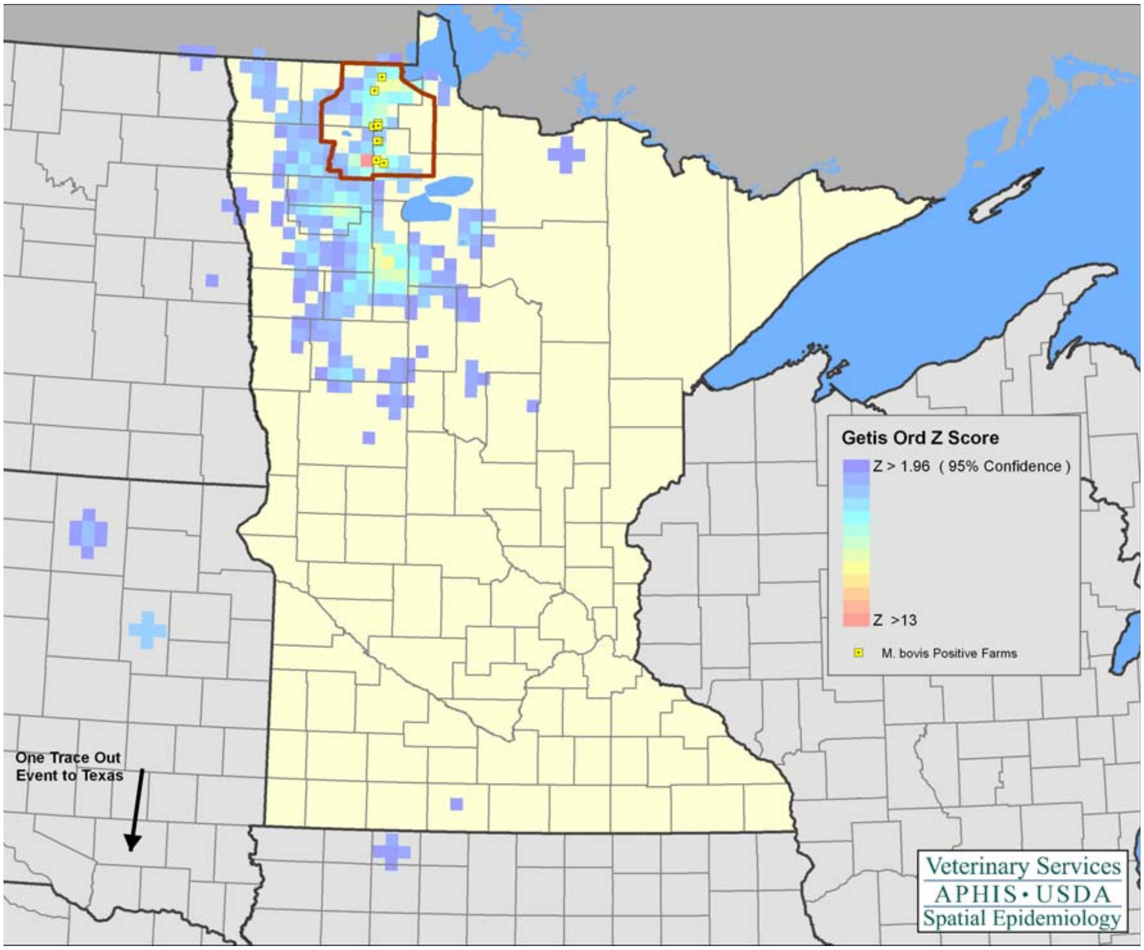

Figure 6b. Getis-Ord GI* clusters of movements out of the proposed MA zone—number of movements.

Methods such as minimum convex polygons and the Getis-Ord Gi* statistic are often used as preliminary or exploratory analyses. However, the results of both analyses indicate some degree of clustering of animal movements and the number of animals moved outside the proposed MA zone. These areas may indicate areas at higher risk of exposure to *M. bovis* both historically and in the future.

Probability of future release through animal movements: Of additional concern are future movement events out of the proposed MA zone by undetected herds prior to the implementation of the MA movement restrictions. As of March 2008, only 245 of 300 herds have had at least 1 WHT since May 2005. However, based on the low sensitivity of the CFT screening test (Se=0.82), it is estimated that some herds may be missed on an annual WHT.

To estimate the number of herds missed on an annual WHT, the same @RISK model (@RISK 2004) used to determine the expected number of false-negative herds was applied. Data from table 5 were used, with the exception that the number of herds tested was changed to 300 and the overall herd prevalence was decreased to random draw from a pert distribution (0, 2, 5) over N.

This was done to reflect the expected decreased overall prevalence due to the depopulation of the 11 herds. The mean number of false-negative herds expected was less than one herd (mean=0.82). The 95-percent confidence interval was 0 to 3 herds.

In order to estimate the probability of having at least one shipment containing at least one infected undetected animal, the following formula was used:

Equation 1

$$C = 1 - \left(1 - \left(p_{herd}\left(1 - \left(1 - \frac{p(1-Se)}{p(1-Se)+(1-p)Sp}\right)^{n}\right)\right)\right)^{k}$$

where:

C=the event of interest

The probability of at least one shipment containing at least one infected animal is:
- k=the number of shipments
- n=the number of animals in a shipment
- P_{herd}=the probability of a herd being declared not infected, when it was truly infected (probability of the herd being false negative)
- p=the within-herd prevalence
- Se=sensitivity
- Sp=specificity

The estimated number of shipments per herd and animals per shipment was derived from the same trace data used to estimate animal movement from the proposed MA zone.

Assuming *M. bovis* is still present in the MA zone, the mean probability that at least one shipment per year contains an infected, undetected animal is 0.13. The 95-percent confidence interval ranges from 0.01 to 0.30. This implies that it is possible for there to be at least one infected animal leaving the proposed MA zone, assuming *M. bovis* transmission is still active. Additional analyses to better refine this number could be conducted; however the data necessary were not available at the time of this analysis. This analysis did not account for animals going to slaughter or the age of cattle in a shipment.

Dairy cattle: According to the Pasteurized Milk Ordinance (PMO), all milk for pasteurization should come from herds in areas that have a Modified Accredited Advanced (MAA) TB status or greater as determined by the USDA. An area which fails to maintain MAA status or greater, must:

1. Be accredited by said Department as TB free;
2. Have passed an annual TB test; or
3. Have established a TB testing protocol for livestock that assures TB protection and surveillance of the dairy industry within the area and that is approved by FDA, USDA,

and the Regulatory Agency (FDA 2003).

In Minnesota's proposed split-State status draft plan (March 11, 2008), all 300 herds within the MA zone would be tested annually. This includes the 19 dairy herds, in accordance with the PMO (fig. 14).

It is impossible to address the risk of bovine TB leaving the proposed MA zone through dairy cattle due to the lack of information available on dairy cattle in this area (e.g., movement and management practices). However, this assessment will describe the current status of dairies in the proposed MA zone and the risk associated with dairies.

As of April 2008, no dairies inside the proposed MA zone have demonstrated evidence of bovine TB infection. Nine of the 19 dairy herds in the proposed MA zone have had a WHT during 2007; 17 of 19 have had at least one WHT since 2005. The mean herd size of these 19 dairies is 77 animals. Minnesota is currently in the process of collecting data from the 19 dairies in the proposed MA zone in order to assess movement and management activities. This information was not available at the time of this assessment.

When dairy herds are infected with *M. bovis,* the within-herd prevalence traditionally appears to be higher than in beef cattle (Morris et al. 1994). Dairy cattle are equally susceptible to *M. bovis* infections, but have certain distinguishing risk factors worthy of separating them from beef cattle. Dairy cows tend to have a longer life span than cattle raised for beef and exhibit different movement patterns.

A study of outbreaks in the Republic of Ireland demonstrated that intensely managed dairy herds were at the greatest risk of chronic bovine TB, compared with other herds (Griffin et al. 1993). The study attributed this risk to the higher degree of stress associated with intensely managed herds, making them more susceptible to *M. bovis*.

Because *M. bovis* can be spread through milk, and milk and colostrum are often pooled for dairy calves, dissemination throughout the herd may happen more rapidly. Dairy cows are also under a great deal of stress between calving and milking. Stress may increase the severity of infection, in turn increasing the shedding of organisms.

According to the National Animal Heath Monitoring System (NAHMS) 2007 Dairy study, approximately 96.5 percent of dairy operations raised their own replacement heifers on-farm; 33 percent relied on pasture during the growing season as part of the ration; 49.3 percent of operations believed their animals had physical contact (and/or water, feed) with deer; 11.3 percent of dairy operations were also in contact with beef cattle operations; and 13.8 percent of all operations required bovine TB testing prior to introduction of new animals. It is important to note that this study represents national-level data and is not specific to Minnesota.

While dairies have several factors for increased transmission and susceptibility, as of April 2008, no infected dairy herds in the proposed MA zone have been identified on a WHT. Two herds have received no testing to date, and eight more have not been tested since 2006. Of the two herds inside the management area, one has been exempt from testing and movement restrictions because the animals are housed indoors. This herd will no longer be exempt with the implementation of the split-State plan. All herds will be required to be tested annually, according to Minnesota's current plan for split-State status. If a herd is identified as infected during this test, additional information will be needed to fully assess the risk to other dairies outside of the proposed MA zone.

Pathway 2: Wildlife

A model of bovine TB in British cattle demonstrated that 75 percent of bovine TB infections were attributed to local-area spread in specific high-risk areas (Brown et al. 1994). Findings in Minnesota thus far appear to be consistent with this model, with 8 of 11 herd infections being attributed to local-area spread. The finding of 61 percent of positive deer within 5.0 km (3.1 mi) of infected cattle premises appears to implicate deer as a potential source of cattle infection.

In the presence of a wildlife reservoir, it may be difficult to distinguish the incidence of infection from fence-line contact and unknown cattle movements versus introduction from a wildlife source. This role of deer as reservoir hosts has been debated in both Minnesota and Michigan. In both circumstances, the temporality associated with infected wildlife in an area and infected cattle has yet to be established. However, the role of deer as sources of transmission of *M. bovis* to cattle has been documented (Palmer et al. 2004a).

Other potential wildlife reservoirs could contribute to the cycle of deer and cattle infections, as demonstrated in other outbreaks around the world. However, this potential has not been explored in Minnesota. Therefore, the role of other wildlife reservoirs will be briefly discussed, but due to the lack of surveillance and information on these species in Minnesota, no analysis can be done at this time.

The following analysis will estimate movements of potentially infected deer to identify areas where the risk of bovine TB may be present.

White-tailed deer: Landscape-scale deer movement can be categorized into two broad categories: annual migratory movements between summer and winter ranges; and dispersal events in which deer move from an established home range and establish a new home range elsewhere. These movement events, migratory and dispersal, pose the greatest risk for long-distance transport of *M. bovis* by white-tailed deer.

Migratory and dispersal movement of white-tailed deer has been well documented in the forest zone of Minnesota (Rongstad and Tester 1969; Kohn and Mooty 1971; Hoskinson and Mech 1976; Nelson and Mech 1984; Mooty et al. 1987; Nelson and Mech 1992; Nelson 1993; Nelson 1995). However, white-tailed deer migration and dispersal have not been investigated as completely for the farmland and transitional zones of Minnesota (Carlsen and Farmes 1957; Brinkman 2003; Burris 2005). The proposed MA zone occupies parts of all three zones of Minnesota; however, all of the *M. bovis*-positive deer have been identified in the transitional zone.

In order to determine the maximum potential risk for an *M. bovis*-positive deer to move via migration or dispersal out of the proposed MA zone, data on the movement of deer were summarized from the literature and applied to the known locations of *M. bovis*-positive deer. Only one study, conducted at Agassiz National Wildlife Refuge (formerly named Mud Lake National Wildlife Refuge), was identified for the region (Carlsen and Farmes 1957). Agassiz National Wildlife Refuge is located in the southwest portion of the proposed MA zone and is approximately 34.0 km (21.1 mi) from the core area. Movement data for other regions of Minnesota and adjacent States were also examined.

Seasonal migration—In the northern part of their range, white-tailed deer are considered a migratory species (Marchinton and Hirth 1984; Demarais et al. 2000). Research has indicated that the onset of cold temperatures and snow depth exert the greatest influence on seasonal movement from summer to winter ranges (Verme 1968; Verme 1973; Nelson 1995). During mild winters with below-average snowfall, deer may occupy the same range year round or only briefly visit a winter range (Drolet 1976; Nelson 1995). Recent winters in northern Minnesota have likely not encouraged a large number of deer to migrate, although some may still move to traditional winter range (Carstensen 2008). When white-tailed deer do migrate, they exhibit high site fidelity, and have been reported to move through suitable habitat en route to previous seasonal range (Tierson et al. 1985). No studies on seasonal migration of white-tailed deer in the proposed MA zone could be identified. However, studies do exist for other regions of Minnesota, North Dakota, and South Dakota (table 10). The observed seasonal migration distance of white-tailed deer reported for adjacent areas ranged from 10.0 to 23.0 km (6.2 to 14.3 mi) (with the mean seasonal migration reported as 15.3 km (9.5 mi) (StDev 4.9 km [3.0 mi]).

Table 10: Observed seasonal migration distances of white-tailed deer

Mean (km)	**Citation**
10.1	(Brinkman 2003)
10.1	(Burris 2005)
15.7	(Griffin et al. 1994)
20.7	(Hoskinson and Mech 1976)
13.0	(Nixon et al. 1991)
20.2	(Sabine et al. 2002)
11.0	(Simon 1986)
23.2	(Sparrowe and Springer 1970)
13.8	(Verme 1973)
15.3	**Mean**
4.9	**St dev**

Within the *M. bovis* management zone, at least two traditional winter ranges (deer yards) are known to exist: one at Thief Lake Wildlife Management Area and the other at Palmville Wildlife Management Area. There are likely other minor deer yards in the area that have not been identified. Thief Lake Wildlife Management Area extends from the core zone west to the edge of the proposed MA zone. Palmville Wildlife Management Area is approximately 8.5 km (5.2 mi) north and west of the core zone on the edge of the management area (fig. 1). Seasonal migration of white-tailed deer is largely a localized event and may not present the greatest risk for movement of an individual *M. bovis*-positive deer outside the proposed MA zone. However, increased densities of deer on winter range, co-feeding on stored feed, and the potential interaction with deer that have summer ranges outside the proposed MA zone do pose a risk for spread and movement of *M. bovis* to adjacent populations and potentially outside the proposed MA zone. Several studies have documented long-term survival of *M. bovis* on many feed types (Palmer and Whipple 2006). The studies also noted co-feeding behavior of deer feeding on frozen feed during the winter, which may increase the potential for transmission. Many laboratory experiments have documented subsequent development of *M. bovis* lesions in deer after environmental exposure to water or feed contaminated with *M. bovis* (Palmer et al. 1999; Palmer et al. 2000; Palmer et al. 2001; Palmer et al. 2004b;).

Dispersal—Fawns, yearlings, and (rarely) adult white-tailed deer may disperse each year, moving from their original home range and establishing a new permanent home range elsewhere (Nixon et al. 1991; Nelson 1993). The amount of dispersal occurring between adjacent deer populations determines emigration and immigration rates, and may represent a significant exchange of individuals between populations (Rosenberry et al.1999), which may be important for the transmission and movement of *M. bovis* at the landscape scale.

Annual dispersal is common for white-tailed deer populations of the Midwest agricultural region (Gladfelter 1984). Fifty percent of female fawns, and 21 percent of yearling females dispersed each spring in Illinois (Nixon et al. 1991). Similarly, Nelson (1993) noted 20 percent of yearling females dispersed in northeast Minnesota. Brinkman (2003) reported that 17 percent of fawns and 5 percent of adults exhibited spring dispersal in southwest Minnesota. Review of the literature indicated that the mean reported dispersal rate was 19 percent for white-tailed deer in Minnesota, Illinois, and South Dakota (table 11). Spring dispersal of juveniles and young adult white-tailed deer that may have had exposure to *M. bovis* on winter range may pose a risk for movement and long-range transport of *M. bovis*.

Table 11. Observed dispersal distances for white-tailed deer

N	Mean (km)	Maximum (km)	Percent dispersing	Citation
77	-	205.0	17.0	(Brinkman 2003)
41	79.94	170.4	20.0	(Burris 2005)
253	53.2	88.5	21.0	(Carlsen and Farmes 1957)*
298	23.8	212.6	-	(Kernohan 1994)
79	55.7	168.0	19.0	(Nelson and Mech 1992; Nelson 1993)
33	111.4	161.0	18.0	(Sparrowe and Springer 1970)
Mean	**64.8**	**167.6**	**19.0**	
St dev	**32.8**	**44.1**	**1.6**	

*Data collected at Agassiz National Wildlife Refuge (formerly Mud Lake National Wildlife Refuge) 21.2 mi (34 km) from the *M. bovis* core area.

Social pressures have been identified as the primary driving force for dispersal (Marchinton 1984). Near parturition, the doe often drives off her previous fawns, encouraging them to disperse (Downing and McGinnes 1969). In intensive agricultural areas with limited available cover, fawns often travel long distances before finding suitable habitat not occupied by other females (Demarais et al. 2000). Dispersal of adult deer is less understood but may also be a result of social pressures and competition for resources in the spring (Brinkman 2003).

Spring dispersal of juveniles and young adult white-tailed deer that may have had exposure to *M. bovis* on winter range may pose a risk for movement and long-range transport of *M. bovis*. However, this risk may be lessened by relatively low rates of infection for fawns and juvenile deer—0 percent (0/204) and 0.2 percent (2/869) respectively (table 7).

Analysis—Data on movement distances for marked white-tailed deer reported for the Agassiz National Wildlife Refuge by Carlsen and Farmes (1957) were used to assign movement probabilities to 1.6-km (1-mi) distance categories from 0 to 88.5 km (0 to 55.0 mi). The data for white-tailed deer (n=57) were used to assign movement probabilities by fitting a Weibull probability model (Johnson et al. 1994). The resulting model was used to approximate the true distribution of movement probabilities for white-tailed deer. Due to time constraints, contemporary model selection techniques were not used and a Weibull probability model was assumed to be the most appropriate model for the data. Figure 7 shows a histogram of movement distances taken from the mark recovery data and the associated Weibull probability model of movement distances. From these data it is clear that the majority of movement occurs within 19 km (12 mi); however, there is probability for movement at great distances. Approximately 25 percent of the probability mass encompasses movement distances greater than 19 km (12 mi). This is consistent with reported deer movement for white-tailed deer in Minnesota and the farmland regions of South Dakota and Illinois (Carlsen and Farmes 1957; Sparrowe and Springer 1970; Nelson and Mech 1992; Brinkman 2003; Nelson 1993; Kernohan 1994; Burris 2005).

This analysis assumes movement of deer is spatially homogenous across the landscape and movement probability and distance do not change with land cover or direction. However, the proposed MA zone includes a significant amount of both heavily forested and farmland habitat. Probability and distance of dispersal are likely to be significantly different in a farmland setting where there is less available habitat, compared to forested habitat where there is more available habitat. This analysis does not account for these differences and assumes that dispersal distance and probability are equal in the two habitats.

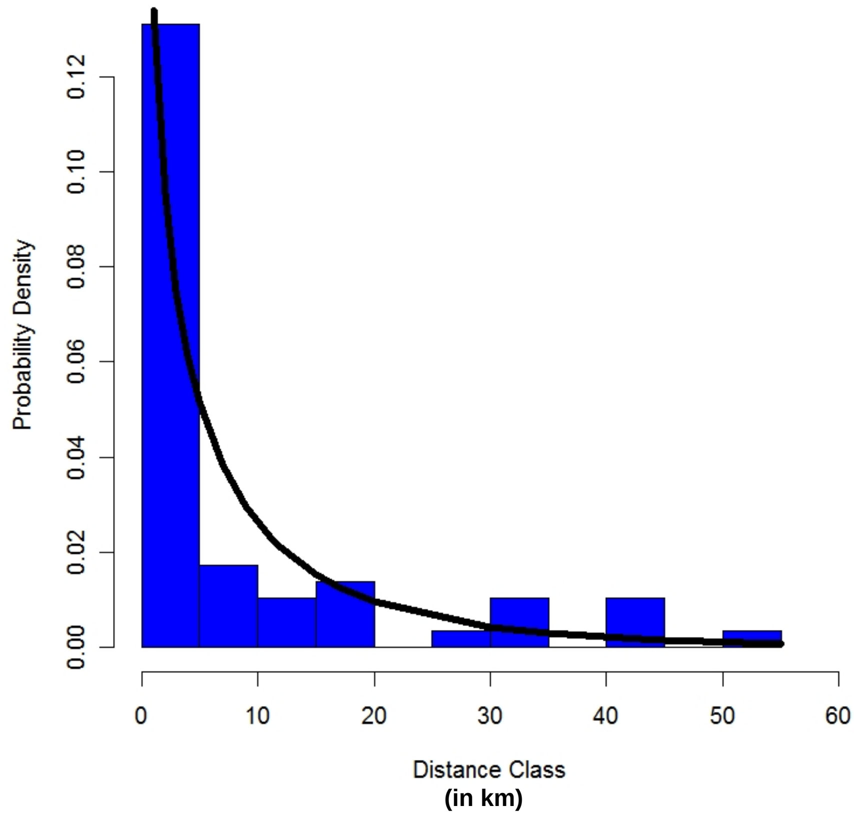

Figure 7. Estimated probability of white-tailed deer movement.

The potential movement of white-tailed deer from areas with *M. bovis*-positive white-tailed deer was estimated using the Weibull probability model of movement distances for the Agassiz National Wildlife Refuge. Figure 8 shows the estimated potential movement of white-tailed deer from areas identified with *M. bovis*-positive deer. Based on the model, the eastern boundary of the proposed MA zone represents 89.0 percent of estimated deer movement; the southern boundary encompasses 79.5 percent; the western boundary encompasses 88.1 percent; and the northern boundary 93.7 percent.

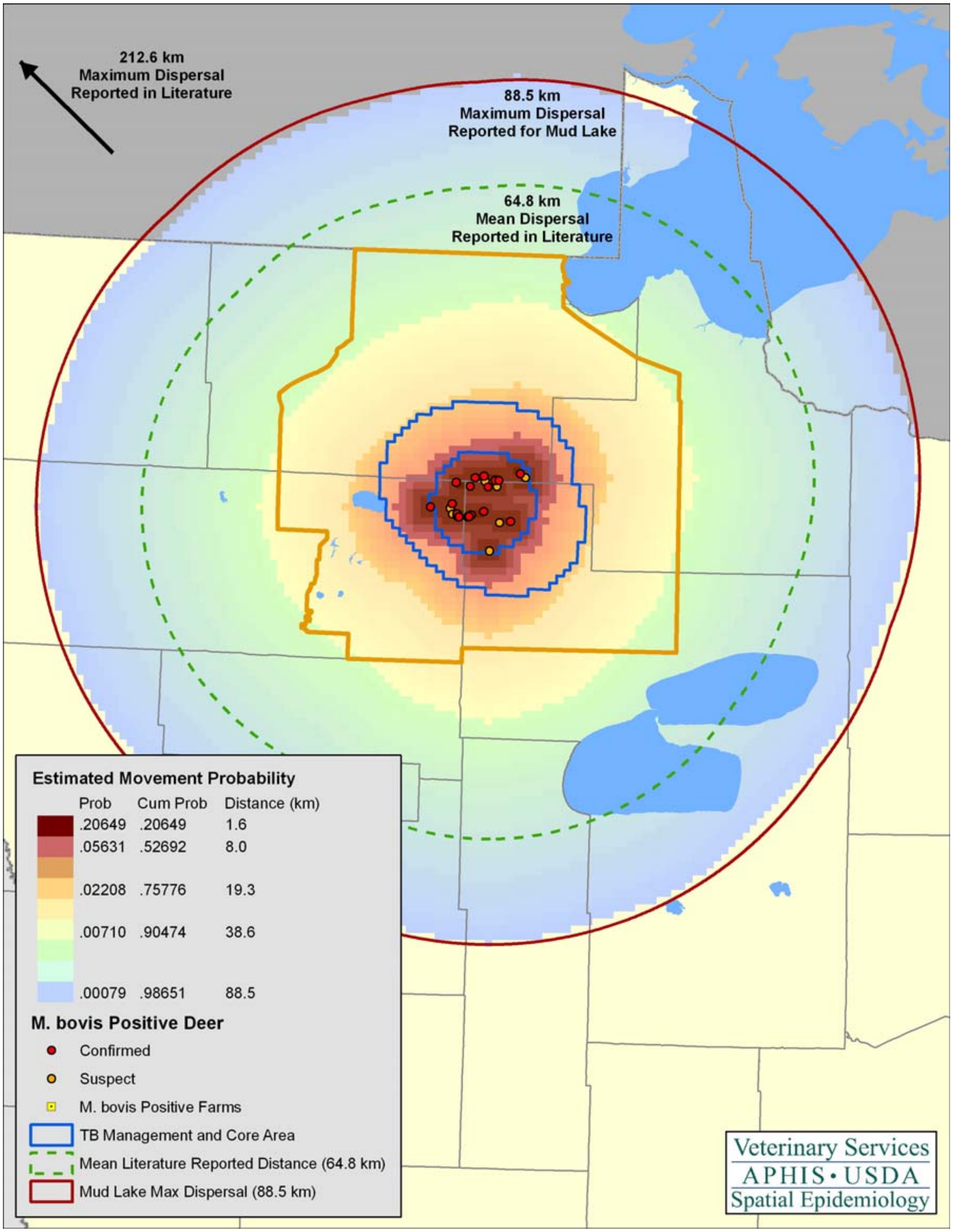

Figure 8. Estimated probability of white-tailed deer movement.[h]

[h] Analysis is based on white-tailed deer movement reported by Carlsen and Farmes (1957).

In order to account for the potential risk of transmission between deer on winter ranges, the movement of deer from known winter ranges should be estimated in future analysis. Currently 55 percent (n=10) of the positive deer and 37 percent (n=3) of suspect deer are located on or within 2.0 km (1.2 mi) of the eastern portion of the Thief Lake deer yard. Thief Lake Wildlife Management Area forms a habitat corridor that extends from the core area west to the edge of the proposed MA zone. Thief Lake Wildlife Management Area may have increased densities of deer during the winter when transmission of *M. bovis* may be higher and as a result it may pose a risk for movement of *M. bovis* via deer outside the proposed MA zone.

However, it is important to note that this analysis represents data that were collected in 1957. Many factors may contribute to a change in deer population dynamics and movement dynamics since these data were collected. Despite these potential changes, the data for the Agassiz National Wildlife Refuge correspond well with white-tailed deer movement reported in the literature (tables 10, 11). Nevertheless, these movements, both seasonal and long-distance, require further investigation in order to fully understand the potential of *M. bovis*-infected deer to move from the proposed MA zone to adjacent populations. In addition, the model did not incorporate survival of dispersing deer, which is often very low. To fully understand the role dispersal may play in the potential movement of *M. bovis,* survival of dispersing individuals should be incorporated into the model structure.

Furthermore, the combined probability of survival of dispersing deer and the effective transmission of *M. bovis* to adjacent populations by dispersing deer is unknown and cannot be determined with the data currently available. Further research is needed to better define the movement dynamics of white-tailed deer in the region, mortality associated with dispersal, and transmission of *M. bovis* between deer.

It is currently uncertain what effect the intensive culling efforts in the core area have on deer dispersal. Several studies have shown that intensive hunting does have an effect on animal behavior and may increase movements or alter annual movements (Roland et al. 1988; Root et al. 1988; Vercauteren and Hygnstrom 1998; Kilpatrick and Lima 1999; Conner et al. 2001). It is unclear if intensive culling (specifically aerial gunning) and increased fall hunter harvest in the core area are serving primarily as a population sink or if these practices have served to disperse some deer outside the core area. Additional information on animal movements, transmission of *M. bovis,* and potential environmental maintenance is needed to better determine the effects of culling and hunting on the population and occurrence of *M. bovis*.

The analysis presented here should be considered exploratory. Data are not currently available to fully predict deer movement, population dynamics, and transmission rates for deer within the proposed MA zone. The assumptions used here—specifically, that data collected in 1957 represent current deer movement—may not be valid given changing climatic and landscape dynamics for the region. In addition, data do not exist to determine if transmission of *M. bovis* between deer is currently occurring or if the current infection is simply spillover from infected cattle operations or a result of exposure to *M. bovis* via contaminated feed.

This analysis provides a good foundation for understanding potential white-tailed deer movement. White-tailed deer pose some level of risk for movement of *M. bovis* outside the proposed MA zone. This analysis identified two potential risks pertaining to deer movement: (1)

the potential movement of dispersing juvenile and young adult deer; and (2) the potential transmission of *M. bovis* between wintering deer on the Thief Lake deer yard. The greatest risk for movement of deer out of the zone based on these two risks is to the south and west.

Elk: Rocky Mountain elk (*Cervus elaphus nelsoni*) may pose some risk for movement of *M. bovis* outside the proposed MA zone. There is one small remnant Rocky Mountain elk herd, known as the Grygla herd, within the proposed MA zone. This herd was originally introduced in 1935 but has been reduced from more than 100 animals to 30 animals due to farmer discontent over crop depredation. The population size is now regulated by a State legislative mandate and is limited to 30 animals. The current population is estimated to range from 30 to 40 elk depending on the reporting source.

There has been documented potential exposure from at least one *M. bovis*-infected cattle herd and the Grygla elk herd. The owner of the herd reported seeing elk co-feeding with his cattle during the winter of 2007–08. The potential exposure occurred after the herd was identified as positive and while it was awaiting depopulation. However, no additional cattle were identified during visual inspection at slaughter. It is unclear if potentially contaminated hay was removed from the premises while the herd was awaiting depopulation which may have posed an exposure risk to elk. In addition, it is unknown if elk were exposed prior to detection of the cattle herd. To date, no positive elk have been indentified.

There is evidence in the literature that elk can serve as a reservoir for *M. bovis* and provide a risk of transmission to cattle. In Manitoba, Canada elk were identified as the primary wildlife reservoir of *M. bovis,* affecting 11 cattle herds between 1992 and 2002. Indirect contact between elk and cattle that had fed on the same large round hay bales was assumed to be the most likely mode of transmission between the species. Hunter-harvest surveillance identified apparent prevalence as high as 4.5 percent for adult male elk (Lees et al. 2003).

The core range for the Grygla elk herd does not extend beyond the proposed MA zone. However, dispersal of juvenile elk, especially juvenile males, can be great and has been reported as far as 149.0 km (92.6 mi) for populations in western States (Petersburg et al. 2000). Dispersal in western States is likely greater than that of elk populations in the upper Midwest. Michigan is currently conducting a long-term movement study of elk in the Upper Peninsula, but the results of the research have not yet been published. There is no available information on dispersal of elk for the Grygla elk herd. Given the exposure of the Grygla elk herd to cattle and feed known to have been exposed to *M. bovis,* this herd does pose some level of risk for movement of *M. bovis*. In addition, because of the low numbers of animals annually sampled, this herd may pose a risk for future maintenance as a reservoir for *M. bovis.* Given the current lack of quantitative data for movement and limited testing of elk, it is not possible to quantify the level of risk posed by this herd.

One additional elk herd is located in northwest Minnesota in Kittson County, approximately 96.6 km (60.0 mi) from the Grygla herd. The Kittson County "border" elk herd spends time in both Minnesota and Manitoba. The population is estimated to be somewhere between 100 and 125 animals with 40 animals permanently residing in Minnesota, and is currently expanding in size. This herd began migrating from Manitoba for summer feeding in the early 1980s but now has individuals that have established permanent home ranges in Minnesota. The movement and dispersal of these elk are largely unknown. This herd does not pose an immediate risk for movement of *M. bovis*. However, exchange of animals between this herd and the Grygla herd is unknown and may occur, presenting some level of risk for movement and transmission of *M. bovis*.

Other wildlife: To date, only white-tailed deer and Rocky Mountain elk have been sampled for *M. bovis* in Minnesota. However, many other species have been shown to play a role in ecology, movement, and environmental persistence of *M. bovis*. Evidence from various countries shows that, given conducive epidemiological circumstances, significant levels of TB infection can be found in feral and free-living wild species such as deer, pigs, badgers, opossums, and coyotes (Lepper and Corner 1983; Morris et al. 1994; Vercauteren and Hygnstrom 1998; Vercauteren et al. 2008). Evidence has also shown that coyotes can serve as an effective sentinel species that can indicate the presence of *M. bovis* in wild white-tailed deer (Atwood 2007;Vercauteren and Hygnstrom 1998; Vercauteren et al. 2008). Given the lack of surveillance data for these alternate host species, it is not possible to quantify overall risk. However, excluding coyotes, the small home range of many of these species indicates that movement of *M. bovis* outside the proposed MA zone is unlikely.

Pathway 3: Fomites

The role of environmental contamination in disease spread in an outbreak is difficult to demonstrate and has often been debated. However, experimental infection demonstrated disease transmission from deer to cattle through feed (Palmer et al. 2004). Infection has also been demonstrated in cattle feeding on pasture contaminated by other infected cattle (Phillips et al. 2003). Because the organism can survive in the environment, feed may serve as a vector for transmission when cattle inhale aerosolized particles (Phillips et al. 2003; Corner 2006).

Hay and other feed stored during winter months pose a concern for the risk of *M. bovis* spread to cattle outside the proposed MA zone. Feed can be contaminated through the feces, urine, or sputum of infected species (Muirhead et al. 1974 and Wilesmith et al. 1982; Brown et al.1994; Phillips et al. 2003). The survival of the organism persists in areas heavily contaminated by fecal matter (Morris et al. 1994). Recovery of the organism from soil, hay, and bedding contaminated with feces has occurred and may serve as a source of infection (Phillips et al. 2003). The weather conditions in northern Minnesota are ideal for the long-term survival of *M. bovis* in the environment.

During the winter months, stored hay is easily accessible to deer and may serve as winter feed. Deer have an affinity for higher quality rations, such as sugar beet pulp and alfalfa, but will eat grass hay when other feed sources are not accessible. A recent study demonstrated the ability for the *M. bovis* to survive on feedstuff contaminated by infected deer. Survival of *M. bovis* in all conditions lasted a minimum of 7 days, but the organism survived as long as 112 days in certain conditions (Palmer and Whipple 2006).

A study by the University of Minnesota in the proposed MA zone revealed that 27 of 53 producers reported some damage to feed by deer (Knust 2008). Minnesota DNR and BAH have made an effort to minimize the contact of deer with stored feed by placing fences around stored feed in areas where *M. bovis* has been detected in deer. The placement of these fences is based on a risk assessment of potential exposure of cattle to deer.

As of March 2008, only 16 fences had been placed; however, more money was allotted by Minnesota to finish fencing in all 56 herds located inside the management areas (fig. 1). A site visit by USDA:APHIS:VS:CEAH in March 2008 evaluated several of the fences constructed. The primary concern associated with the current fences is the effectiveness of the gates. Deer may pass through spaces as small as 25 cm (Feldhamer et al. 1986). In one instance, a gap large enough for a human to walk through was noted on a gate comprised of panels spaced too far apart (fig. 9).

Figure 9. Large spaces in a gate built to keep deer out of stored hay in the TB Management Area. (Photo by USDA:APHIS:VS:CEAH)

On some premises, owners had elected not to erect the fences despite being offered this option after a risk assessment of the deer/cattle contact potential was evaluated. Occasionally deer have been reported inside some fences when owners have left the gate open. Other owners were using the fence to store straw or other low-risk materials while the hay was being used as a windbreak. Deer tracks were noted near several unprotected grass hay bales and near other feed sources seen inside the management area.

For some purposes, such as controlling crop damage, fences that effectively minimize the introduction of deer to an area by only 50 percent may be cost effective. However, when deer may transmit diseases to livestock, fences need to be 100-percent effective (Vercauteren et al. 2006). The effectiveness of any fencing system depends on adequate maintenance, the design of the fence, and the operation of the gate. Additional work is being done by the University of Minnesota and USDA:APHIS:WS to evaluate the effectiveness of fences or other alternative strategies to further minimize deer/cattle interaction. This work should be used to help identify more effective methods for reducing exposure of cattle and feed to deer.

The potential movement of contaminated hay outside the proposed MA zone poses a concern. Currently the majority of the hay produced inside the proposed MA zone is thought to stay inside the proposed MA zone; however, no data were available on hay movement. Because hay is currently unregulated in the proposed zone, producers can freely move hay outside the MA zone. In one instance, hay was observed by USDA:APHIS:VS:CEAH being moved from a previously infected premise to an unknown destination. This hay was stored with no biosecurity to prevent exposure to deer.

Feed may serve as a potential fomite for bovine TB transmission, either deer-to-deer or deer-to-cattle (Palmer and Whipple 2006). Additional efforts are needed to minimize exposure of stored feed to prevent the potential transmission of bovine TB to cattle in the proposed MA zone. The movement of potentially contaminated feed from the MA zone, particularly from the management area, will likely increase as owners participate in the buyout. Restrictions are needed for the movement of feed out of the proposed MA zone. Discarding feed should be included as a standard in cleaning and disinfection protocols for infected premises, or considered as a requirement with the current buyout.

Section 4: Exposure Assessment

This exposure assessment will define the populations at risk in the proposed AF zone and evaluate the adequacy of testing in this zone to detect the presence of *M. bovis*.

4.1 Description of the proposed AF zone

Cattle operations are dispersed across all districts[i] of Minnesota, but the cattle industry is not uniformly distributed throughout the State, and different segments of the industry tend to be located in different districts across the State. Only the Northeast district and the East Central district do not have counties represented in the top 10 of at least 1 segment of the cattle industry (fig. 18).

Cow-calf operations tend to be more widely distributed than other segments of the industry (fig. 20). The top 10 counties with beef cow operations are located in the Northwest, North Central, West Central, Central, and Southeast districts.

Dairy operations tend to be located in a band from west central to southeast Minnesota (fig. 21). The top 10 counties with milk cow operations are located in the West Central, Central, and Southeast districts.

Cattle feeding operations are concentrated in the southwest part of Minnesota (fig. 19). Six of the top 10 counties with cattle feeding operations are located in the Southwest district, and other counties are located adjacent to this district. The remaining counties are located in the Central and Southeast districts.

Table 12. Number of cattle in Minnesota by class, 2004–08

Class	2004	2005	2006	2007	2008
All cattle and calves	2,400	2,400	2,350	2,420	2,400
All cows that have calved	860	855	835	860	860
Beef cows that have calved	395	395	390	405	397
Milk cows that have calved	465	460	445	455	463
Beef cow replacement	100	95	95	100	100
Milk cow replacement	280	270	265	270	270
Other heifers >500 lb	190	190	170	175	175
Steers 500 lb and over	450	440	450	460	445
Bulls 500 lb and over	35	40	35	35	40
Calves under 500 lb	485	510	500	520	510
Calf crop	850	820	830	840	
Cattle and calves on feed	310	290	290	285	305

[i] Districts are described in Minnesota Agricultural Statistics 2007.

4.2 Surveillance of cattle herds in the proposed AF zone

This section evaluates testing efforts in the portion of the State requesting AF status.

In order to evaluate if testing is adequate to meet the requirements for an AF zone,[j] this assessment evaluates the testing efforts conducted in this proposed zone based on Minnesota's 2006 Management Plan. In particular, the analysis addresses the following two risk questions:

1. Is the completed one-time statewide testing (fig. 16) of the cattle population outside the proposed MA zone adequate to detect the presence of *M. bovis* in cattle at the assumed herd design prevalence of 0.2 percent (i.e., 2 in 1,000) with 95-percent confidence?
2. Is the proposed follow-up random sampling of 149 herds every 2 years from the cattle population of approximately 25,700[k] herds outside the proposed MA zone enough to meet the CFR requirement of detecting infection at the 2-percent (i.e., 2 in 100) prevalence with 95-percent confidence based on Minnesota's current plan for split-State status (Appendix 5)?

This section evaluates the adequacy of testing to detect TB if it currently exists or were introduced in the future in Minnesota's cattle population[l] in the proposed AF zone by addressing the following questions:

1. Is the sample size of 1,497 herds sufficient to detect TB in the proposed AF zone?
2. Is the proposed random testing of 149 herds (conducted over a period of 2 years) adequate to ensure continued freedom from TB in the proposed AF zone?
3. Is the time period of sampling appropriate, both for testing of the 1,497 herds and the proposed 149 herds thereafter?
4. Do significant differences exist in test response rates between different geographic areas throughout the State that could suggest differences in true prevalence?

The analysis takes into consideration important characteristics of bovine TB[m] and the capabilities of the three tests—CFT, CCT, and mycobacterial culture of lymph nodes or gross lesions—applied in series to detect TB in a herd in the proposed AF zone. It is assumed that this sequence

[j] Requirements for qualification of AF status from an MA zone are not outlined in the CFR or 2005 UM&R for bovine TB. However, requirements for qualification of AF from an MAA Zone are outlined in 9 CFR 77.9 and the UM&R.

[k] The current plan for split-State status (MN BAH 2008) indicates a herd size of 25,700. The original sampling was based on a population 21,300 as written in the 2006 Management Plan (MN BAH 2006).

[l] Based on the sampling design of the one-time testing and the data provided, this assessment could not distinguish the adequacy of testing in dairy versus other cattle herds. It is assumed that all herds are at similar risk of exposure.

[m] Characteristics of the disease considered include but are not limited to: minimum prevalence (at both herd and within-herd levels) that any testing is to detect, the confidence required of doing so, a minimum period for the testing, a minimum interval until a herd can be re-tested, an adequate geographic spread of tested herds, and measures to be taken to guard against the introduction of new infection (Cannon 2002).

of testing would effectively result in a 100-percent specific test. That is, any positive tests were resolved in such a way that there would be no false-positive herds.[n]

(1) Is the sample size of 1,497 herds sufficient to detect TB in the proposed AF zone?

In determining the number of WHTs needed to detect *M. bovis* in the proposed AF zone, Minnesota's plan assumes a herd design prevalence of 0.2 percent and calculates the number of herds needed to be sampled at 1,497.[o] This sample size may be too small since it assumes 100-percent sensitivity of the CFT screening test.

The following formula was used to calculate the sample size of 1,497 herds to be tested in Minnesota:

Equation 2

$$n \geq \frac{\ln(1-\gamma)}{\ln(1-p)} = \frac{\ln(1-0.95)}{\ln(1-0.002)} = 1497$$

$$\begin{aligned} \text{where} \quad \gamma &= \text{Level of confidence} = 95\% \\ p &= \text{Design herd prevalence in the area} = 0.002. \end{aligned}$$

This formula (Vose 2000) assumes a perfect test sensitivity and specificity (i.e., Se=Sp=100 percent) and that the sampled population of herds is infinitely large. The assumption of perfect sensitivity results in an underestimation of the sample size required to detect TB in the cattle population at the assumed 0.2-percent prevalence and the 95-percent statistical confidence.

In order to account for the low sensitivity of the screening test, a more appropriate formula to calculate sample size would be:

Equation 3

$$\begin{aligned} n \;\square\; & \frac{\left(1-(1-\gamma)^{1/D}\right)\left(N-\frac{1}{2}(Se \cdot D-1)\right)}{Se} \\ &= \frac{\left(1-(1-0.95)^{1/51}\right)\left(25,700-\frac{1}{2}(0.82 \cdot 51-1)\right)}{0.82} \\ &= 1,774 \end{aligned}$$

$$\begin{aligned} \text{where} \quad \gamma &= \text{Level of confidence} \\ N &= \text{Total number of herds in area} \\ D &= \text{Number of infected herds in area} \\ Se &= \text{Test sensitivity} \end{aligned}$$

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[n] The potential for false negatives still exists due to the low sensitivity of each test and lower sensitivity of these tests in series.

[o] The 2006 testing plan was not developed just for the AF zone and, thus, the few herds tested inside the MA zone should not be considered as part of the statewide testing of 1,497 herds. However, in this analysis all whole-herd tests were used in calculating the statistical confidence associated with efforts to demonstrate absence of disease in the AF zone.

This formula (Cannon 2001) considers the sensitivity of the screening test and the total number of herds from which to sample in the area under consideration. Assuming the number of cattle herds in Minnesota is 25,700 and the herd design prevalence is 0.2 percent (i.e., 2 in 1,000), then the expected number of infected herds in the population is D=25,700x0.002=51. With a test sensitivity Se=0.82 and a 95-percent statistical confidence, the above formula gives a minimum number of herds to sample of 1,774. (It is important to point out that all 1,774 herds should come from the proposed AF zone. Testing of herds in the proposed MA zone should be additional.) This is the sample size that should have been proposed instead of 1,497.

(2) Is the proposed random testing of 149 herds (conducted over a period of 2 years) adequate to ensure continued freedom from TB in the proposed AF zone?

To calculate the minimum sample size of herds necessary to monitor and detect *M. Bovis* in Minnesota's population of cattle herds within the proposed AF zone in the future (if Minnesota would be considered free), the same formula (equation 2) was used. However, the level of desired detection was 2-percent prevalence with 95-percent confidence based on 9 CFR 77.4.

Equation 4

$$n \geq \frac{\ln(1-\gamma)}{\ln(1-p)} = \frac{\ln(1-0.95)}{\ln(1-0.02)} = 149$$

where γ = Level of confidence=95%

p = Design herd prevalence in the area=2%

Again, this formula assumes a perfect test sensitivity and specificity and that the population of herds is infinitely large. This assumption gives an inadequate sample size for the assumed CFT sensitivity of 0.82. Using the formula described earlier (equation 3) the minimum necessary sample size to detect *M. bovis* with 95-percent confidence at the assumed design prevalence of 2 percent is 181 herds instead of 149.

(3) Is the time period of sampling appropriate, for testing both the 1,497 herds and the proposed 149 herds thereafter?

In the context of TB sampling in Minnesota, the issue of time associated with the one-time Statewide testing of 1,497 herds and for the random testing of 149 herds thereafter is fundamentally important for the validity of inferences made to the sampled population. The population of herds from which the sample of *n* herds is taken is a dynamic population that changes continually. If the sampled population of herds at risk changes significantly, by the time all 1,497 sampled herds are tested, then inferences from test results may not apply to the current changed population. Therefore, it is important that sampling take into consideration any significant changes to the original population (e.g., animals culled and animals purchased from out-of-state as replacements). This may be accomplished by increasing the sample size accordingly and/or by using time series or repeated measures type of sampling (i.e., by sampling the same herds multiple times) to account for the temporal changes and correlations between observations.

All the analyses conducted in this section are valid only if it can be assumed that the cattle population in Minnesota has not changed significantly from May 2005 until the end of the one-time sampling period. If significant changes have occurred to the cattle population in Minnesota during its one-time statewide testing designed to demonstrate freedom from *M. Bovis* in the proposed AF zone, then the proposed sample of 1,497, which is already underestimated, is stretched even further. In this case, one cannot be sure that the sample size of n=1,497 herds (or even n=1,774) will be adequate to detect *M. bovis* with 95-percent confidence at the specified design prevalence of 0.2 percent. The length of the time period during which sampling is conducted must be better specified, as well as the changes in Minnesota's cattle population each year.

The same argument applies for the proposed followup random sampling and testing of the 149 herds (or the more appropriate 181 herds). That is, unless epidemiological arguments that the population is not changing significantly are offered to defend the proposed (already underestimated) number of herds at 149 to be sampled over 2 years, this sample size may not be adequate to detect *M. bovis* at the 2-percent design prevalence with 95-percent confidence. If the population is changing significantly, then either the sample size must be increased accordingly or sampling of the population must be adjusted to incorporate such dynamic changes (a time series type of sampling to assess trend in prevalence).

In the case of Minnesota, the actual number of WHTs that were conducted was 2,141, involving 1,885 unique premises (some premises were visited multiple times). This number is larger than both the proposed 1,497 and the more adequate 1,774. However, these herds were tested (with some re-tested) over a period of 2 1/2 years (57 herds were tested in 2005; 923 in 2006; 1,135 in 2007; and 26 in 2008). Again, if the population of cattle herds has changed significantly during this period of sampling and testing, then using all 1,885 premises to support the argument for demonstrating the absence of *M. bovis* in the proposed AF zone may not be accurate. The effective sample size to use in making such an argument would be 923 (from 2006) or 1,135 (from 2007), depending on which point in time one considers the starting point for the time period for sampling. Once time is defined more clearly, then these data may be revisited and analyzed accordingly. Only then can one assess the adequacy of the sample size for the purpose of demonstrating absence of *M. bovis* in the proposed AF zone at the specified design prevalence, and for assessing trend in prevalence over time with measurable statistical confidence. In this analysis, all data from 2005 until now were lumped together to estimate prevalence in the proposed AF zone.

(4) Do significant differences exist in test responses between different geographic areas throughout the State that could suggest differences in prevalence?

Significant differences in test response rates between different geographic areas in the State could suggest differences in true prevalence. However, several confounders could also account for these differences, such as differences in test handling and interpretation, or the presence of other mycobacterial organisms. These analyses examine differences in CCT and CFT response rates only to determine if differences do in fact exist. Additional analyses are required to identify the significance of these findings and role of additional variables.

To test for differences in test response rates between different geographic areas throughout the State, test data were stratified by:

1. Event reason—based on the reason the herd was tested for *M. bovis*;
2. Minimum convex polygons—based on the movement of animals from the MA zone; and
3. Proximity to trace-out herds—based on 10-km (6.2-mi), 20-km (12.4-mi), and 40-km (24.9-mi) grids.

Evaluation of CCT response rate based on event reason: To subset the data based on the event reason,[p] the data were collapsed into five categories, similar in terms of epidemiologic significance:

1. Management Area (MA)—herds tested inside of the designated management area;
2. Trace (TRACE)—herds tested as a result of being traced to or from the infected herds;
3. Northwest Minnesota (NWMN)—herds that were located in the northwest portion of Minnesota (these herds were tested at a higher frequency);
4. Statewide testing (SWS) (fig.17)—herds throughout the rest of Minnesota tested for a part of the Statewide sampling scheme outlined in the 2006 TB Management plan (Minnesota BAH 2006); and
5. Other (OTHER)—which contained herds tested for various reasons, not necessarily for epidemiologic purposes.

A statistical test using Analysis of Variance (ANOVA) was conducted to test the null hypothesis of equal CCT response rates[q] between different event reasons. The null and alternative hypotheses are:

$$H_0 : \mu_{\text{MA}} = \mu_{\text{TRACE}} = \mu_{\text{NWMN}} = \mu_{\text{SWS}} = \mu_{\text{OTHER}}$$

$$H_1 : \mu_i \neq \mu_j \quad \text{for at least one } i, j$$

where μ_{MA}, μ_{TRACE}, μ_{NWMN}, μ_{SWS} and μ_{OTHER} represent the mean CC response rate for each of the event reasons defined above—MA, TRACE, NWMN, SWS, and OTHER, respectively.

The linear statistical model describing the observations used for testing the above null hypothesis is:

[p] The event reason recorded in the data provided by Minnesota is the reason the herd was tested.

[q] Both suspect and reactor rates were used because, as a measure of precaution during 2005–March 2008, Minnesota was considering all responders as CCT reactors, rather than waiting for a followup test in 60 days.

Equation 5

$$y_{ij} = \mu + \tau_i + \varepsilon_{ij} \begin{cases} i = 1, 2, \dots, a \\ j = 1, 2, \dots, n_i \end{cases}$$

where y_{ij} is the (ij)th observation - the CC response rate for event reason i and herd j
μ is the overall mean rate of CC test,
τ_i is the i^{th} mean rate of CC test,
ε_{ij} is the random error component
i represents zones, $i = 1, 2, 3, 4, 5$
j herd j, where $j = 1, 2, \dots, n_i$
n_i number of herds tested for event reason i

Here $n_{\text{MA}} = 39$, $n_{\text{NWMN}} = 251$, $n_{\text{TRACE}} = 75$, $n_{\text{SWS}} = 396$, and $n_{\text{OTHER}} = 145$

Of the 1,885 WHTs, only 906 herds reacted to the CFT and were followed up by CCT (fig. 16). The data used in this ANOVA model were the 906 herds tested with the CCT, which included: 396 herds from the SWS event reason, 251 from NWMN, 145 from OTHER, 75 from TRACE, and 39 from the MA event reason.

The analysis of variance calls for the rejection of the null hypothesis of equal CCT response rates between the five event reasons (p-value=0.0007). In other words, there is statistical evidence to suggest that significant differences in CCT response rates between the event reasons do exist. However, the findings are questionable since the statistical test assumes the data have a normal distribution, which they do not, as evidenced by the low R^2 value of 0.021064 (table 19).

Table 13 gives the mean CCT reactor rates, the number of herds tested with the CCT, and the 95-percent confidence intervals for those means in each event reason. Notice the mean CCT response rate is higher in herds tested in northwest Minnesota and those inside the management area, compared to those herds in the statewide surveillance program (table 20).

Table 13. Mean CCT response rates and their corresponding 95-percent confidence limits in each event reason

Event reason	N	Mean	95% confidence limits	
OTHER	145	0.0058077	0.0037701	0.0078453
NWMN	251	0.0018634	0.0003147	0.0034121
MA_ZONE	39	0.0015279	-0.0024010	0.0054567
TRACE	75	0.0007584	-0.0020748	0.0035915
SWS	396	0.0005526	-0.0006803	0.0017856

Evaluation of CCT response rate based on minimum convex polygons: The second stratification used the minimum convex polygons based on movement events (fig. 5) from the infected herds to stratify the data for statewide sampling of cattle for *M. bovis*. Each sampling event was stratified into one of the six categories representing estimated percentiles of cattle movement—0, 25, 50, 75, 90, and 95 percentiles (fig. 5)—with category 0 representing the farthest distance from the infected area where no movement was known to have occurred.

A similar analysis was conducted using the minimum convex polygons stratification strata (fig. 5) to test for differences in CCT rates associated with cattle movement from the proposed MA zone (based on traced outs *and* traced in herds). Here, too, is statistical evidence of differences at the 5-percent level of significance (p-value=0.0463) (table 22). However, these differences are not as large as those associated with the first stratification (table 21).

Table 14. Mean CCT reactor rates and their corresponding 95-percent confidence limits in each of the minimum convex polygons movement strata

TALL[r]_Zone	N	Mean	95% confidence limits	
90	105	0.0046339	0.0022276	0.0070402
25	198	0.0030494	0.0012970	0.0048017
75	96	0.0018020	-0.0007146	0.0043186
50	218	0.0011677	-0.0005023	0.0028377
95	78	0.0007929	-0.0019990	0.0035849
0	211	0.0003100	-0.0013875	0.0020075

Evaluation of CFT response rates based on distance to trace-out herds: The CFT is the screening test used to identify bovine TB in cattle. An animal's response to a CFT indicates that animal's capacity to mount an immune response to *M. bovis.* However, this response is not specific for *M. bovis* and herds with exposure to other mycobacterial organisms would have a high percentage of caudal fold responders. An estimated response rate is outline in the 2005 UM&R and can be used as a measure of performance in veterinarians reading CFTs (fig. 15).

In Minnesota, performance standards are applied to accredited veterinarians to ensure adequate testing for bovine TB. After July 2006, all accredited veterinarians who performed the CFT on cattle and bison were required to undergo additional training. During FY 2007, 364 accredited veterinarians conducted CFTs in Minnesota; 138 of these conducted more than 300 tests. The mean CFT response rate has increased slightly from 2005 to 2007, but it is unknown if this is due to training or to increased testing efforts by Federal and State veterinarians. (From the annual report submitted to USDA for CFT suspects: FY05—70,352 CFT tests, 995 responders (1.41 percent); FY06—85,554 CFT tests, 1,222 responders (1.43 percent); FY07—182,563 CFT tests, 3,282 responders (1.80 percent).)

Because of the high number of false positives associated with a CFT, results can be difficult to interpret. One or more suspect animals in a herd warrants a herd quarantine and additional testing

[r] TALL is all traces, both into an out of an infected herd.

of those animals with a CCT, bovine interferon gamma assay, or shipment under permit, directly to slaughter.

A high caudal fold response rate may indicate herd exposure to *M. bovis* or another *Mycobacteria sp.* Regardless, a high caudal fold response rate in a herd indicates the need for additional testing. Using data provided by Minnesota as a result of bovine TB testing conducted throughout the State, the geographic distribution of high caudal fold response rates of herds tested outside the proposed modified accredited zone was evaluated (fig. 10). A high caudal fold response rate was considered 3.7 percent or higher within a herd. This represented the 75th percentile of herds tested (e.g., 75 percent of the herds tested had CFT response rates less than 3.7 percent).

The caudal fold response rates of herds inside a 10.0-km (6.2-mi), 20-km (12.4-mi), or 40.1-km (24.9-mi) grid compared to their proximity to herds identified as trace-outs were compared. A trace-out herd was identified as a herd that has received animals from an infected herd within 5 years prior to detection in that herd. Statistical analysis demonstrated an association of high caudal fold response rates to finding a trace herd within a certain distance (fig. 10, table 15). The odds ratio for a high caudal fold response rate of herds in a 20.0-km (12.4-mi) grid with a trace-out also identified inside that grid compared to herds without a nearby trace-out was 5.4 ($p<0.0001$).

Table 15. Association of geographic areas with high caudal fold response rates with trace herds, by grid size

Grid size (km)	**Chi^2**	**P**	**Odds ratio**	**Confidence intervals**	
10 x 10	67.019	<.0001	3.9545	2.8124	5.5603
20 x 20	45.0360	<.0001	5.3543	3.1957	8.9708
40 x 40	9.4813	0.0021	4.1163	1.6058	10.5519

As demonstrated through the above analyses, differences in test response rates between different geographic areas in the State seem to depend on how the testing conducted in Minnesota is stratified. Additional analysis to better understand the significance of these differences may include Johne's surveillance data, the presence of poultry operations, and the administrator of the test (private and public veterinarians).

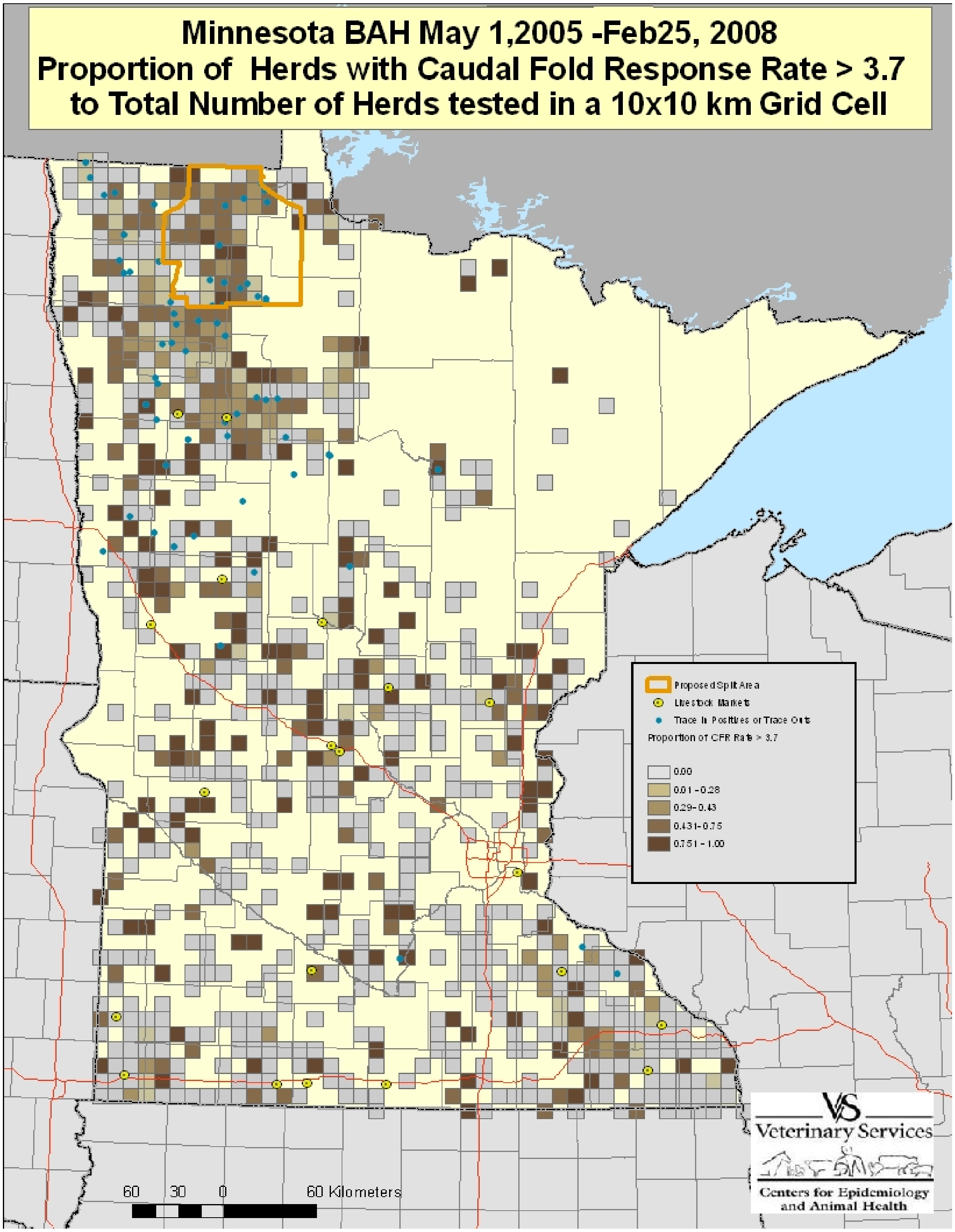

Figure 10. 10-km grids indicating the proportion of high caudal fold response rates (>3.7) to the number of herds tested in the grid.

Summary: The testing section evaluated testing efforts in the portion of the State requesting AF status. The conclusions of the analysis in this section may be summarized as follows:

1. The proposed sample size of 1,497 for conducting a one-time testing underestimates the number of herds needed to detect at least 0.2-percent prevalence with 95-percent confidence. A more appropriate sample size would be 1,774.
2. Similarly, the sample size required for future testing in the proposed AF zone to monitor and detect *M. bovis* at the UM&R-required 2-percent (i.e., 2 in 100) herd prevalence with 95-percent confidence is underestimated. The proposed sample size was 149 herds over 2 years. A more appropriate minimum sample size is 181 herds.
3. The analysis concluded that unless the time period and population are better defined, the proposed sample size of 149 herds (or even the more appropriate sample size of 181) to be tested in the future every 2 years is not adequate to detect *M. bovis* at the proposed 2-percent (i.e., 2 in 100) herd prevalence with 95-percent confidence.
4. The analysis concludes that statistically significant differences in test response rates between different geographic areas do exist. This may serve as a guideline for future targeted surveillance. However, additional analyses are needed to evaluate the role of other confounders.

4.3 Sampling of deer in the proposed AF zone

In addition to sampling within the TB Core and Management Zones, Minnesota DNR conducted a one-time statewide sampling for *M. bovis* using hunter-collected samples during the firearms deer hunting season in fall 2006. Statewide sampling collected a total of 4,000 samples, 3,000 north of Brainerd and 1,000 south of Brainerd. Figure 11 presents the results of the statewide sampling. Sampling did not detect *M. bovis* outside the proposed MA zone.

The results of this statewide sampling effort were compared with the estimated fall deer population by deer permit area for 2006 to determine if enough samples were collected to detect *M. bovis* at 1-percent prevalence with 95-percent confidence. Analysis was conducted to determine if enough sampling had been conducted to detect *M. bovis* in areas adjacent to the proposed MA zone. For areas within the proposed MA zone the total number of fall samples for 2005, 2006, and 2007 was used.

White-tailed deer populations in Minnesota are estimated and reported by permit area. Populations are estimated using accounting models that subtract losses occurring from harvest and nonharvest mortality, add gains in the form of newborn fawns, and keep a running total of the number of animals in each sex-age class during successive seasons of the year. These models are recalibrated every 4 to 5 years using aerial and ground surveys (Grund and Woolf 2004; Grund et al. 2005; Haroldson et al. 2005).

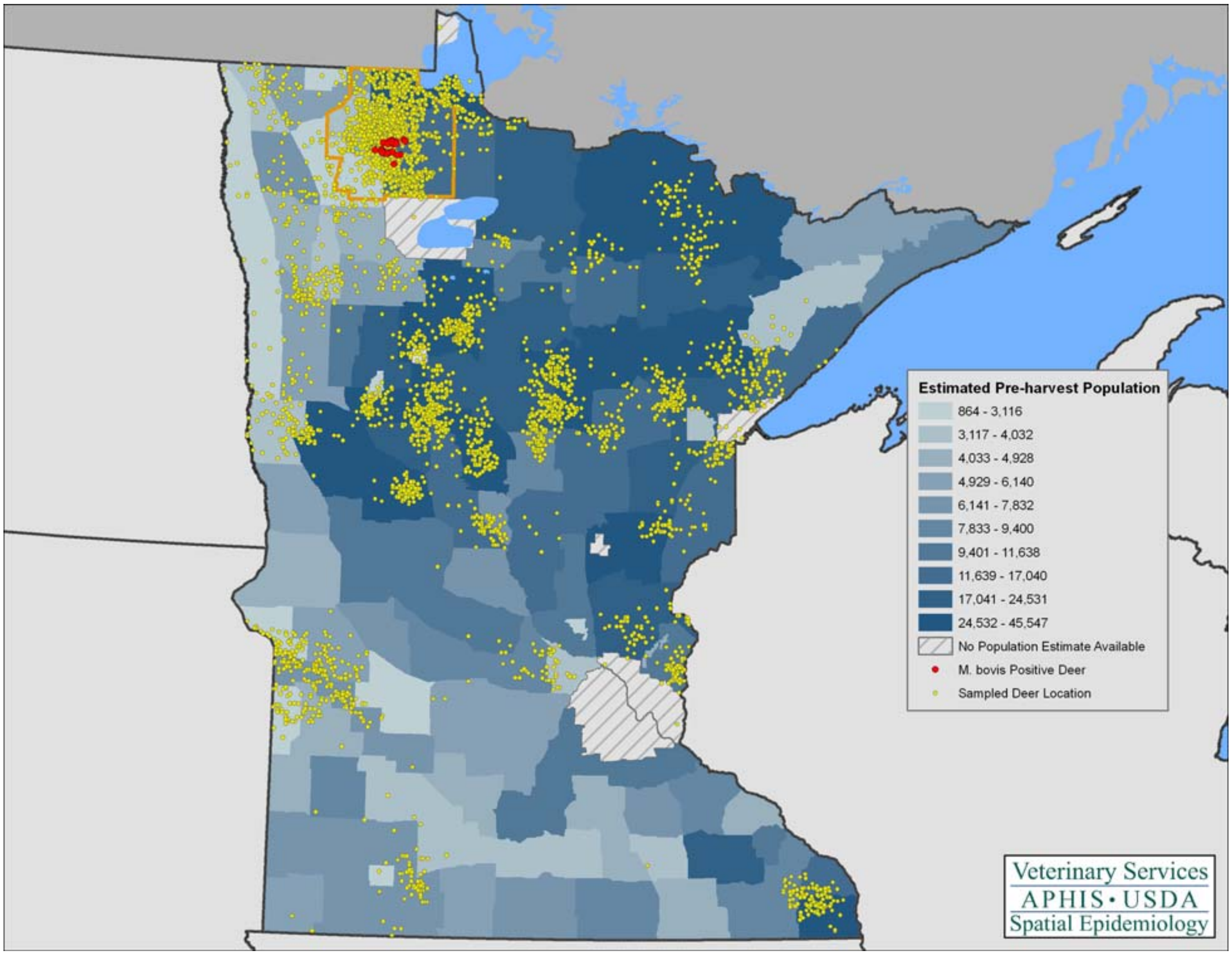

Figure 11. Location of 2006 statewide *M. bovis* samples for white-tailed deer.

To calculate the sample size needed by permit area, the following sample-size calculation (equation 6) was used (Cannon, 2001).

Equation 6

$$n \cong \frac{(1-(1-\alpha)^{1/D})(N - \frac{1}{2}(SeD-1))}{Se}$$

Because test sensitivity can greatly affect the estimated number of samples needed to detect disease, the required sample size was calculated for three levels of test sensitivity—65, 75, and 85 percent.

Several caveats are associated with this analysis. First, this analysis does not take into account the spatial heterogeneity of sampling or deer populations within the permit area. Some regions of a permit area may be sampled more intensely than other areas, resulting in differing detection probability across the permit area. In addition, some regions of a permit area may not have been sampled. Sensitivity of detection can greatly affect the number of samples required and maybe significantly lower than the assumed 65 percent. In addition, error in the calculation may also result from imprecise estimates of white-tailed deer populations.

According to the calculation, the samples required by permit area to detect *M. bovis* at 1-percent prevalence with 95-percent confidence ranged from 297 to 458 depending on the level of test sensitivity. The estimated total number of samples required for permit areas within and adjacent to the proposed MA zone ranged from 3,687 to 4,826. The estimated number of statewide samples required ranged from 41,752 to 54,635.

Table 16 represents the estimated number of samples required to detect *M. bovis* and the number of samples collected during the 2005, 2006, and 2007 fall sampling effort for permit areas within and adjacent to the proposed MA zone. Figure 12 illustrates the percentage increase in sampling required to meet the estimated number of samples needed for detection of *M. bovis* at 1-percent prevalence and 95-percent confidence.

Table 16. Estimated number of samples for areas within and adjacent to the proposed MA zone

Permit Area		**Estimated 2006 Population**[1]		**Number of Fall Samples**				**Estimated Sample Size (%)**[2]		
		Preharvest	Prefawn	2005	2006	2007	Total	65	75	85
104	Adjacent	22,858	16,624		27	1	28	457	396	349
201	Adjacent	1,288	966		6		6	411	356	314
202	In Zone	1,884	1,256	20	77	121	218	425	369	325
203	In Zone	1,521	936		9	4	13	418	362	319
204	In Zone	5,026	3,590	9	58	9	76	447	387	341
205	In Zone	34,470	26,810	159	313	222	694	458	397	350
206	In Zone	3,297	2,355	143	259	335	737	440	381	336
207	Adjacent	2,700	1,800		12		12	435	377	333
208	In Zone	2,658	1,772	9	40	75	124	435	377	332
209	Adjacent	4,473	3,195		40	1	41	445	385	340
211	In Zone	15,372	8,540	130	407	390	927	455	395	348
213†	Adjacent	No estimate available				3		3		
214‡	Adjacent	No estimate available				1		1		
Total		**101,091**	**71,540**	470	1,252	1,158	2,880	4,826	4,182	3,687

[1] Estimated deer population by permit area.
[2] Estimated number of samples needed to detect disease at 1-percent prevalence with 95-percent confidence at differing levels of test sensitivity.
† Permit area entirely encompasses the Red Lake Nation Reservation.
‡ Permit area is separated from proposed management zone by Lake of the Woods.

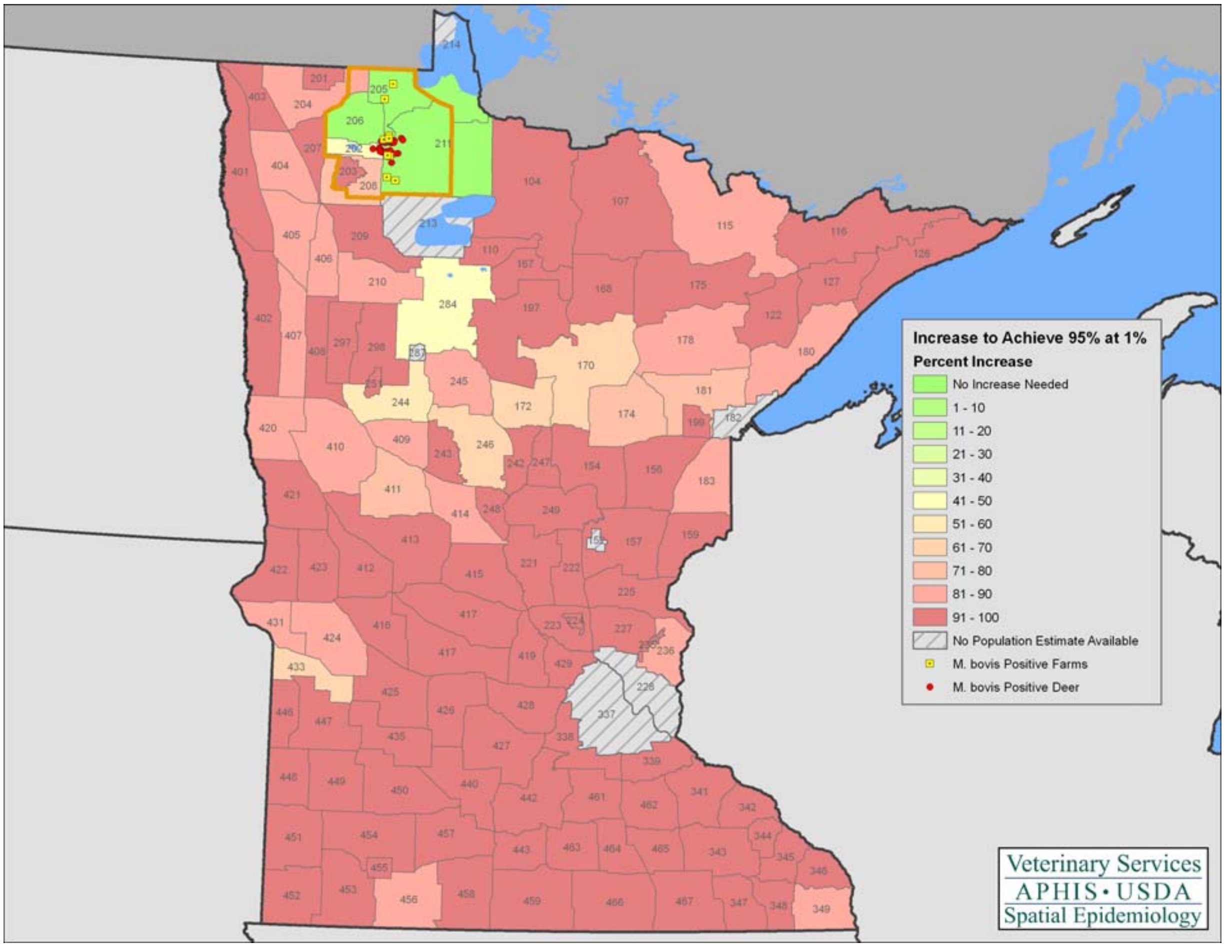

Figure 12a. Estimated increase in sampling of white-tailed deer to needed to achieve detection (test sensitivity of 65 percent).

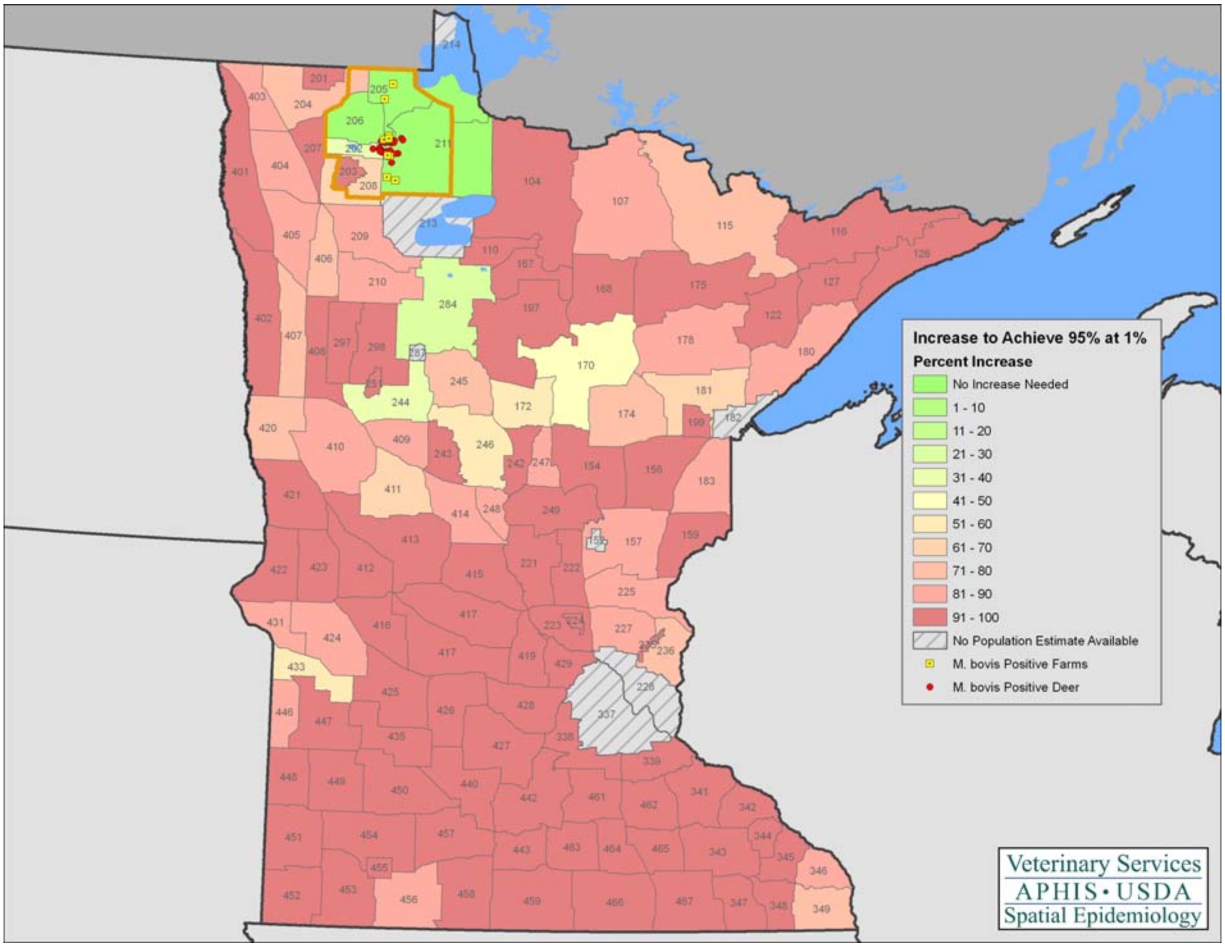

Figure 12b. Estimated increase in sampling of white-tailed deer to needed to achieve detection (test sensitivity of 85 percent).

According to this analysis, sampling adjacent to the proposed MA zone does not appear to be sufficient to detect disease at the 1-percent prevalence level. According to this analysis, sampling within the proposed MA zone approaches the number of samples needed for detection at the 1-percent level of prevalence, except in the extreme southwest portion of the proposed MA zone. Several factors may contribute to the low number of samples in this region of the proposed MA zone. Deer density is relatively low in this region and likely occurs in small isolated pockets, which may not be easily accessible to hunters, limiting both harvest and sampling. Estimates of deer population may also be less accurate in regions with low deer densities.

In addition, sampling within the permit areas is highly clustered and the spatial heterogeneity of sampling and deer populations was not considered in this analysis. Some regions of a permit area may have received enough sampling to detect disease while other regions have not been sampled. An example of this is permit area 211. The majority of the sampling in this permit area is within the proposed MA zone; however the permit area extends 28.0 km (17.4 mi) east of the proposed MA zone and few samples have been collected in this region of the permit area.

Section 5: Consequence Assessment

5.1 Biological consequences

Due to the time constraints and priorities of this risk assessment, a comprehensive impact assessment of the biological consequences associated with Minnesota's current plan for split-State status was not conducted. A brief historical overview of the current strain of *M. bovis* in Minnesota may help demonstrate the potential impact of bovine TB in the proposed AF zone.

The current strain of bovine TB in the proposed MA zone has been detected in 11 of 1,885 herds subjected to a WHT from May 2005–March 2008. The apparent within-herd prevalence was 3 percent, which is lower than other outbreaks that have been reported. However, transmission of *M. bovis* appears to be active in this zone.

If the likelihood of at least one undetected, infected animal leaving the proposed MA zone is considered, then the likelihood of at least one herd in the proposed AF zone having bovine TB must also be considered. In this situation, prevalence in the proposed AF zone may stay below 2-percent prevalence. Therefore, a low number of infected animals may persist undetected in the AF zone. The sampling efforts outlined by Minnesota (149 every 2 years) would not be adequate to detect a low prevalence. An alternative approach would be targeting high-risk herds in the proposed AF zone based on potential exposure to deer, cattle, and other fomites leaving the proposed MA zone.

5.2 Economic consequences

In order to attain split-State status, a State must demonstrate, among other things, that it has the financial resources to implement and enforce a TB eradication program (9 CFR 77). Executive Order 12866 requires that APHIS assess both the costs and benefits of the proposed split-State status application as it relates to its regulations and adopt it only on a reasoned determination that the benefits justify its costs (Federal Register 1993).

Minnesota ranks sixth among States in agriculture production in the United States, accounting for $9.8 billion in farm income in 2006. Production of cattle and calves ranks fifth among agricultural categories in Minnesota. Receipts from production of cattle and calves contributed $925.5 million directly to the State's economy in 2006. In 2007, Minnesota cattle producers exported over $3 million in live cattle, primarily to Mexico and Canada.

The four counties comprising the proposed MA zone account for 7.3 percent of beef cow numbers in Minnesota, 0.9 percent of milk cow numbers, and 2.3 percent of sheep numbers. No cattle feeding or hog production operations are listed for the four counties. In 2005, livestock production accounted for $54.1 million, or 23 percent of agricultural receipts in the four counties. Production of sheep and goats is relatively insignificant. Although the impact of the plan on economic activity in the four counties comprising the proposed MA zone has not been estimated at this time, it is likely to be significant.[s]

Only small portions of each of these counties are included in the proposed MA zone, and the management area within the proposed MA zone is significantly smaller. Thirty-three percent of cow-calf operations and 22 percent of dairies in the four counties are located in the proposed MA zone.

The cost of split-State status will be shared among several entities. Those entities directly bearing costs include the Federal government through USDA:APHIS; the State of Minnesota; cattle producers in the proposed MA zone; and cattle producers in the proposed AF zone. Other entities potentially bearing costs include residents of the four counties surrounding the proposed MA zone, and Minnesota deer hunters.

Minnesota's application for split-State status is an effort to minimize these costs while preventing further spread of *M. bovis*. Much of the economic impact of this plan will be limited to the proposed MA zone. The benefit of split-State status would be calculated as the difference between the cost, given the status of the entire State is Modified Accredited, versus the cost given MA status is limited to portions of Beltrami, Marshall, Lake of the Woods, and Roseau Counties (and the status of the rest of the State is Accredited Free). This assessment did not evaluate the effect on the rest of the state in MAA versus AF status.

Costs to producers both inside and outside the proposed MA zone have not been estimated. Cattle producers outside the proposed MA zone will be subject to an assessment of $1 per head for all cattle marketed in 2009. Minnesota BAH estimates the amount of revenue from this source to be $1,221,000.

Legislation that creates a cattle herd buyout plan was recently signed into law. The plan will impact the number of operations and affected cattle in the proposed MA zone. Producers in the proposed MA zone are considering several factors that will affect their decision to remain in the industry. Because of the uncertainty surrounding many of the factors that go into a producer's decision, the number of operations and cattle that will remain in the proposed MA zone is unknown. These are the fundamental statistics required to budget for and allocate resources to Minnesota's proposed plan. These producers' decisions will impact costs to producers outside the proposed MA zone and the State's budget.

The impact of downgrading Minnesota's TB status from MAA to MA has not been fully estimated at the time of this assessment. However, the cost of testing alone was estimated to be $29.1 million per year. This estimate does not account for economic losses to cattle producers from discounted cattle prices and increased production costs, increased costs to State and Federal agencies to meet increased requirements with respect to eradication and control measures, and adverse impacts to State and local economies in the form of lost income and jobs. The total cost (of the entire State in MA status) to the Minnesota economy is likely to be significantly higher than $29.1 million per year.

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[s] Additional studies underway by Minnesota Department of Agriculture may provide additional information.

The BAH has developed a budget of $20,371,620 (present value) over the next 10 years to accomplish its goal of eradicating bovine TB in the proposed MA zone. APHIS has requested $2,633,000 from the Commodity Credit Corporation (CCC) to support this effort. Present value of funding for the State of Minnesota's plan over the 10-year period is $18,435,961 ($25,422,142 in nominal terms). Assuming that BAH activities for 2008 have been adequately funded in previous legislation and that the Minnesota Legislature will continue to fund the program at current levels, funding will match expected costs for the 10-year plan. Both APHIS and Minnesota's proposed budgets address fundamental elements of the plan and funding requests as known at this time would adequately fund these projected costs.

Section 6: Risk Estimation

In order to evaluate the risk associated with the spread of bovine TB from the proposed MA zone, all the elements discussed above must be considered. The decisions associated with Minnesota's current plan for split-State status should be based on the following questions:

1. Is active *M. bovis* transmission still present in deer or cattle in the proposed MA zone?
2. Are all identified areas of high risk currently contained within the proposed MA zone?
3. Is Minnesota's proposed plan for split-State status sufficient to mitigate all risk pathways for *M. bovis* transmission outside the proposed MA zone?
4. Has sampling in the proposed AF zone been adequate to demonstrate that livestock and wildlife are not at risk of being infected with *M. bovis*?
5. Are future surveillance efforts in the proposed AF zone sufficient to demonstrate the required design prevalence, based on the potential risks in that zone?
6. Has the State demonstrated the financial resources to implement and enforce the proposed split-State plan?

6.1 Is *M. bovis* transmission still active in deer or cattle in the proposed MA zone?

Evidence of active transmission of bovine TB in the proposed MA zone is supported through epidemiological analysis of the recently discovered herds. The low number of cattle infected and age of animals infected, combined with the low probability that all these herds were previously undetected, suggests that recent exposure and infection have occurred in cattle. Evidence of recent infection elevates the risk of TB being transmitted outside the MA zone.

The source of these recent cattle infections is unknown. No positive deer have been identified outside the core area, but 4 of the 11 infected cattle herds were outside this area. This could indicate that deer outside this core area are infected, yet undetected due to lack of adequate sampling to detect a low prevalence. Another possible explanation is that the source of infection is something other than deer, such as feed, other wildlife movements, unrecorded cattle movement, or some type of environmental exposure.

All deer confirmed positive as of April 2008 were alive in 2005. However, it is not possible to determine when or how these deer were exposed to *M. bovis*. In addition, laboratory results are currently pending for a suspect juvenile female deer which was culled in spring 2008 and that was not alive in 2005. The continued identification of *M. bovis*-positive deer with no reduction in apparent fall hunter-harvest prevalence may indicate active infection in the deer population.

6.2 Are all identified areas of high risk currently contained within the proposed MA zone?

This analysis identifies three primary pathways for *M. bovis* transmission outside the proposed MA zone: movement of cattle, wildlife, and hay or other fomites. The area that each of these high risk movements encompasses is much larger than the proposed MA zone (figs. 5, 6, 8).

For cattle movements, the currently proposed MA zone only captures a small percentage of annual movement from the area where *M. bovis* is known to exist (8 to 13 percent of animals moving and 17 to18 percent of all shipments). From the disease control perspective, the most effective approach is to cover as much of the true population at risk as possible. The true population at risk is the network of producers that had the potential for direct contact with infected animals via animal movements.

The smaller the proportion of the producers at risk covered by surveillance and control activities, the more likely bovine TB has already, or will, spread outside the MA zone.
Recently (April 22, 2008) the BAH imposed movement restrictions on animals leaving the management area (fig. 1); however, movement occurred freely prior to those restrictions. At the time of this writing, herds outside the management area, but still within the proposed MA zone, were allowed to move freely. Given the time lag and difficulty of identifying *M. bovis* in cattle, it is likely that other infected herds have not yet been identified, either inside or outside the proposed MA zone, due to direct contact with animals leaving the proposed MA zone. In addition, trace-back investigations from the recently infected herds were not complete at the time of this analysis.

For hay and other fomites, it was impossible to quantify the risk of bovine TB leaving the MA zone, due to a lack of data availability. However, based on observations made during the USDA:APHIS:VS:CEAH site visit in March, hay exposed to either infected cattle or deer could leave the zone. The current lack of regulations for hay movement poses an additional concern. Fences intended to limit deer contact with cattle feed may not be sufficient. In addition, these fences will be erected only on the 56 premises inside the management area. Based on the potential movement of deer in the proposed MA zone, feed in the outer portion of the proposed MA zone could be exposed to infected deer as well.

This analysis also demonstrated that deer dispersal may extend beyond the boundaries of the proposed MA zone. It is possible that *M. bovis*-infected deer have dispersed outside the core area (figs. 8, 12) and have not yet been detected. However, long-range dispersal is a low probability event. Dispersal is more likely to occur with young deer (fawns and juveniles), but the survival rate of dispersing individuals is not known for the area and is often very low. While the majority of the infected deer identified have been adults, at least two juvenile deer were identified and culture results are pending on an additional suspect juvenile. Additional analysis would be necessary to determine the probability of infected deer leaving the proposed MA zone. Preliminary findings suggest that the size of the proposed MA zone does not fully encompass the expected range at which infected deer can disperse. However, the proposed MA zone does encompass expected seasonal movements.

6.3 Is Minnesota's proposed plan for split-State status sufficient to mitigate all risk pathways for future *M. bovis* transmission outside the proposed MA zone?

For effective containment of bovine TB, appropriate mitigation efforts should be applied to each of the three primary transmission pathways identified in this assessment. Though the possibility exists for bovine TB to be transmitted to cattle herds outside the proposed MA zone via any of these pathways, it was beyond the scope of this analysis to estimate the frequency and rate at which this could occur.

Currently Minnesota's plan for split-State status does not contain steps to mitigate transmission via hay or other fomites. Without regulations in place to prevent hay and other feed sources from leaving the proposed MA zone, this could serve as an uncontrolled source of introduction.

The mitigation efforts to prevent *M. bovis* transmission through animal movements are consistent with the CFR and UM&R requirements. In addition to movement testing, Minnesota intends to test all cattle herds inside the proposed MA zone on an annual basis. Despite these testing efforts, it is estimated that at least one infected undetected animal leaving the zone during the next year is still likely ($p=0.13$). Based on the low within-herd prevalence and the unknown destination of potentially infected animals (slaughter vs. breeding site), it is unknown whether or not bovine TB would be established in the proposed AF zone via this pathway.

White-tailed deer do pose a potential risk for movement outside the proposed MA zone. This analysis provides a good foundation for understanding potential white-tailed deer movements; however it was not possible to fully predict the probability of infected animals leaving the proposed MA zone. This analysis identified two potential risks pertaining to deer movement: (1) the potential movement of dispersing juvenile and young adult deer beyond the proposed MA zone boundary; and (2) the potential transmission of *M. bovis* between deer wintering on the Thief Lake deer yard. The greatest risk for movement of deer outside the proposed MA zone, based on these two risks, is directly to the south and west.

In addition, it is currently uncertain what effect intensive culling efforts in the core area will have on deer dispersal. Several studies have shown that intensive hunting does have an effect on animal behavior and may increase movements or alter annual movements (Roland et al. 1988; Root et al. 1988; Vercauteren and Hygnstrom 1998; Kilpatrick and Lima 1999; Conner et al. 2001). It is unclear if intensive culling (specifically aerial gunning) and increased fall hunter harvest in the core area are serving primarily as a population sink or if these practices have served to disperse some deer outside the core area. Additional information on animal movements, transmission of *M. bovis,* and potential environmental maintenance is needed to better determine the effects of culling and hunting on the population and occurrence of *M. bovis*.

6.4 Has adequate sampling been conducted in the proposed AF zone to demonstrate livestock and wildlife are not at risk of being infected with TB?

According to the 2005 UM&R (USDA:APHIS 2005), to qualify for AF status, a State or zone must have conducted adequate surveillance to demonstrate livestock herds and wildlife are not at risk of being infected with TB based on a risk assessment. In addition, the minimum UM&R requirement for MAA status is a demonstrated herd prevalence of 0.01 percent or less for each of the most recent 2 years, and a 0 prevalence for AF status (or 2 years of adequate surveillance since the last herd was depopulated to demonstrate herds in the zone are not at risk of becoming infected).

The statewide sampling of cattle conducted in Minnesota was adequate to detect 0.2-percent prevalence with 95-percent confidence if the data from 2005–07 can be combined and the cattle population has not changed substantially during this time. The analysis in this section identified a major issue that could have serious consequences on the validity of any statistical inferences made from the sample to the entire population from which it came. The issue is the ill-specified time period for sampling the population of herds, for both the one-time sampling and the future sampling of the herd population in the proposed AF zone.

To evaluate the testing efforts in the proposed AF zone, this analysis overlooked the time issue and combined all sampling data collected since 2005 (i.e., all 1,885 herds) to estimate the herd prevalence in the proposed AF zone. Combining data was necessary in order to estimate the herd prevalence in the proposed AF zone at the proposed level of confidence of 95 percent. Had the analysis assessed prevalence using uncombined yearly data, Minnesota's proposed confidence of 95 percent would not have been possible.

In addition, the statewide surveillance for bovine TB ended at the end of 2007; therefore, it is possible recent events have introduced *M. bovis* outside the proposed MA zone. Surveillance in the targeted high-risk populations outside the proposed MA zone should continue prior to or after implementation of the split-State plan, if the zone size is not increased to ensure *M. bovis* was not introduced in the high-risk areas since 2007.

The historic statewide surveillance effort was not designed to target adjacent deer populations which have a higher likelihood of contact with deer leaving the proposed MA zone. Not enough samples have been collected adjacent to the proposed MA zone to detect disease. Therefore it cannot be conclusively determined if the statewide surveillance in deer outside the proposed MA zone demonstrates the absence of disease. Targeted surveillance of deer populations adjacent to the proposed MA zone which may be at risk or the use of sentinel species (determined by this analysis) should be considered.

It may also be beneficial to sample specific sentinel carnivore species such as coyotes or wolves to better determine the extent of *M. bovis* infection in the surrounding deer populations. Studies have shown that detection of *M. bovis* in deer populations may be dramatically improved by using sentinel species such as coyotes. In a study in Michigan using coyotes as a sentinel species researchers found that if coyotes had been substituted for deer surveillance, 97 percent fewer deer would have been sampled and the likelihood of detecting *M. bovis* would have increased by 40 percent (Atwood et al. 2007; Vercauteren et al. 2008). Because apparent *M. bovis* prevalence is probably <1 percent and current sampling strategies are designed to detect *M. bovis* at a prevalence >1 percent, using coyotes or other sentinel species may increase the ability to detect *M. bovis* in deer populations.

6.5 Are future surveillance efforts in the proposed AF zone sufficient to demonstrate the required design prevalence, based on potential risks in that zone?

Minnesota's plan outlines the testing of 149 herds over 2 years to meet the CFR requirement (9 CFR 77.3) of the detection of 2-percent prevalence with 95-percent confidence in the overall cattle population in the proposed AF zone. This design is made with the assumption that there is currently no *M. bovis* in the proposed AF zone and little risk of introduction in the future. Using this assumption and accounting for a low test sensitivity and specificity, testing 181 herds on an annual basis would be better than using 149 herds to meet USDA's minimum requirements.

However, given that the risk of exposure to bovine TB has continued to occur outside the proposed MA zone and may continue to occur after the implementation of the proposed mitigation efforts, additional targeted surveillance is warranted to demonstrate the absence of *M. bovis* in the proposed AF zone. In addition, surveillance in deer populations in the proposed AF Zone is necessary to demonstrate the risk of *M. bovis* to cattle in that zone.

6.6 Has the State demonstrated the financial resources to implement and enforce the proposed split-State plan?

The Minnesota BAH has developed a budget of $20,371,620 (present value) over the next 10 years to accomplish its goal of eradicating bovine TB in the proposed MA zone. A CCC funding request through APHIS has been approved to support this effort. Both budgets address fundamental elements of the plan. Present value of funding for the State of Minnesota plan over the 10-year period is $18,435,961 ($25,422,142 in nominal terms). Assuming that BAH activities for 2008 have been funded in previous legislation and that the legislature will continue to fund the program at current levels, funding will match expected costs for the 10-year plan.

Costs to producers both inside and outside the proposed MA zone have not been estimated. The benefit to the State is the cost to the entire State in MA status minus the cost to only those areas inside the proposed MA zone. While the total cost of the entire State in MA status has not been estimated, the cost to the area inside the proposed MA zone is estimated to be much smaller.

The costs to APHIS and the State of Minnesota are outlined in their current estimated budgets. However, the costs to the producers inside the proposed MA zone cannot be estimated at this time. The decisions these producers make will have an impact on costs to producers outside the proposed MA zone and to the State’s budget.

Section 7: Alternative Mitigations

The following alternative mitigation options are suggested for consideration, additional options should also be considered. Given the timeline for this risk assessment, it was not possible to evaluate these options to determine the effectiveness or cost-benefit associated with these alternatives.

1. In order to best capture the potential risk of historic exposure events, one alternative is that the proposed MA zone be enlarged to include a greater portion of deer and cattle movements from the infected area.

2. Implementation of continued cattle and deer sampling in high-risk areas outside the proposed MA zone, identified through this risk assessment, could help ensure the absence of *M. bovis* and rapid detection of potential introduction in the future.

3. Deer-culling efforts could be concentrated on populations outside or on the outer boundary of the proposed MA zone. Common disease control efforts concentrate on containing the disease and then working inward to reduce or eradicate disease. Working from the inside out, as is the current approach to deer control in Minnesota, may serve to spread disease.

4. Regulations on hay and other feedstuffs, which apply to all premises inside the proposed MA zone, could be developed and implemented.

5. Surveillance could be conducted in other wildlife species inside the proposed MA zone to help work toward demonstrating freedom from *M. bovis* in the zone.

Section 8: Data Limitations

Due to the time constraints place on this risk assessment and the absence of data in some instances, the analyses presented in this document should be considered exploratory.

This assessment could not evaluate risk based on production type. The only data available for cattle movements were trace data from the 11 infected herds, which were used to represent the entire proposed MA zone. No data were available for the movement of dairy cattle in the MA Zone. Additional information on production types, management practices, herd size, and movement from the other 289 herds (particularly the 19 dairies) in the proposed MA zone would be useful.

Further analysis is required to better define the risks associated with wildlife, specifically white-tailed deer. It is possible to characterize deer movement within the proposed MA zone. Contemporary population dynamic models could be used to estimate deer movement and the potential movement of individual deer outside the proposed MA zone. However, telemetry data describing movement dynamics of deer in the zone are needed. This type of analysis would be useful to further quantify the probability of *M. bovis*-positive deer moving outside the proposed MA zone. In addition, specific information concerning habitat types and preferences could also be used to better understand differing spatial risks for movement of deer. Telemetry data or preferably GPS data on deer movements could be used to characterize potential contact rates between cattle and deer. Analysis of these data could better define relative risks associated with deer and aid in optimizing mitigation of these risks.

No data are available on surveillance in other wildlife species in Minnesota. Numerous studies indicate the role of other mammals in *M. bovis* transmission. Surveillance in these species could help Minnesota with the eradication process.

To better understand the significance of CFT and CCT results as indicators of risk for bovine TB, the role of other potential confounders and risk factors should be explored. This could include factors such as the test administration and presence of other mycobacterial organisms.

Other data necessary for more thorough analysis and risk estimation include data on hay movement, studies to improve the effectiveness of deer fences, and additional cost-benefit analysis to compare various mitigation strategies. Many of these studies are currently underway by the University of Minnesota and others. These studies should continue to be funded to help with the eventual eradication of bovine TB in the proposed MA zone.

It would be possible to develop a formal social network using graph theory to predict areas of greater connectivity and, in turn, greater risk for exposure and infection of *M. bovis*. Furthermore, it would be possible to incorporate probability of detection and *M. bovis* latency to estimate probability of undetected infection of *M. bovis* for specific regions of Minnesota. There is a well-established body of literature and methodology on the subject of social networks related to disease and disease spread (Potterat et al. 1999; Liljeros et al. 2003; Meyers et al. 2003; Meyers et al. 2006). The results of this movement analysis could be incorporated with other risk factors, such as white-tailed deer movements and hay movements, to estimate overall risk, as was done in England (Wint et al. 2002).

In addition, this methodology could be used to determine, based on economic costs associated with movement restrictions and testing, the most effective means of limiting exposure to *M. bovis* while incurring the least cost to producers and the State of Minnesota.

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Paul Wolf, USDA APHIS WS MN

Appendix 1: Definitions

Affected herd: Herd that has had at least one culture-confirmed positive animal and has been declared a bovine TB-infected herd by the State of Minnesota to USDA:APHIS.

Accredited-free State or zone: A State or zone that is or is part of a State that has the authority to enforce and complies with the provisions of the "Uniform Methods and Rules-Bovine Tuberculosis Eradication" and in which tuberculosis is prevalent in less than 0.5 percent of the total number of herds of cattle and bison in the State or zone (9 CFR 77.5).

Approved State-Federal market: Shall refer to and include the sale of cattle from a designated premises that has been approved by the board and Federal agency (Minnesota Office of the Revisor of Statutes 2006).

Incubation period: The period of time that elapses from the infection of the host by the agent to the appearance of clinical symptoms.

Market premises: The premises where a sale is conducted and shall include, but not be limited to, temporary or permanent sales rings, pens, and alleys for confining cattle prior to and after sale, and any land or building contiguous to such sales rings where cattle may be brought, unloaded, or confined prior to sale or after sale before delivery to the purchaser (Minnesota Office of the Revisor of Statutes 2006).

Modified accredited: A state or zone that is or is part of a State that has the authority to enforce and complies with the provisions of the "Uniform Methods and Rules-Bovine Tuberculosis Eradication" and in which tuberculosis is prevalent in less than 0.1 percent of the total number of herds of cattle and bison in the State or zone for most of the recent year(9 CFR 77.5).

Modified accredited advanced: A state or zone that is or is part of a State that has the authority to enforce and complies with the provisions of the "Uniform Methods and Rules-Bovine Tuberculosis Eradication" and in which tuberculosis is prevalent in less than 0.01 percent of the total number of herds of cattle and bison in the State or zone for most of the recent 2 years (9 CFR 77.5).

Period of communicability: The period of time during which an infected host remains capable of transmitting the infective agent.

Prepatent period: The period between the infection of the host by the agent and the detection of the agent in the tissues or secretions of the host.

Reservoir host: A vertebrate animal species that harbors a particular pathogen and acts as a long-term source of infection for other vertebrates or vectors.

Responder: Animals with a detectable swelling on a tuberculin skin test (CFT in cattle).

Appendix 2: Additional Data Tables

Table 17. History of whole herd tests in the six recently discovered herds

Infected herd	EVENT RSN	DATE	Test type	Num NEG	Num SUS	Num POS	Num TESTED
6	ADJ	2005	CF	18	0	0	18
	RETEST	2006	CF	14	1	0	14
	RETEST	2006	CC	0	0	1	1
7	AREA	2006	CF	35	2	0	37
	AREA	2006	CC	0	1	1	2
8	TOUT	2006	CF	189	6	0	195
	TOUT	2006	CC	6	0	0	6
	RETEST	2007	CF	55	2	0	57
	RETEST	2007	CC	0	0	2	2
9	AREA	2005	CF	197	12	0	209
	AREA	2005	CC	12	0	0	12
	RETEST	2006	CF	226	7	0	233
	RETEST	2006	CC	7	0	0	7
	MANAGE	2007	CF	247	6	0	253
	MANAGE	2007	CC	5	0	1	6
10	ADJ	2005	CF	40	0	0	40
	RETEST	2006	CF	29	0	0	29
	RETEST	2006	CF	6	0	0	6
	CORE	2008	CF	60	2	0	62
	CORE	2008	CC	0	0	2	2
11	AREA	2006	CF	31	0	0	31
	CORE	2007	CF	61	3	0	64
	CORE	2007	CC	2	0	1	3

Table 18. Production types of herds tested from January 2005 - February 2008

Production type	Number of herds tested
Unknown	2
Beef	1,429
Dairy	334
Mixed	110
Grand total	**1,875**

Provided by: Minnesota Board of Animal Health.

Table 19. ANOVA table showing model results for testing differences in CCT response rates between the five event reasons

Source	DF	Sum of squares	Mean square	F value	Pr>F
Model	4	0.00303010	0.00075753	4.85	0.0007
Error	901	0.14081898	0.00015629		
Corrected total	905	0.14384908			

R-square	Coeff var	Root MSE	cc_sus_rate mean
0.021064	688.4830	0.012502	0.001816

Source	DF	Type III SS	Mean square	F value	Pr>F
Risk zone	4	0.00303010	0.00075753	4.85	0.0007

Table 20. Least significant differences (LSD). Pairwise differences in mean CCT reactor rates between the five event reasons and their corresponding 95-percent confidence limits of the differences

(Comparisons significant at the 0.05 level are indicated by ***.)

Event reason comparison		Difference between means	95% confidence limits		
OTHER	- NWMN	0.0039443	0.0013850	0.0065036	***
OTHER	- MA_ZONE	0.0042798	-0.0001460	0.0087056	
OTHER	- TRACE	0.0050493	0.0015598	0.0085391	***
OTHER	- SWS	0.0052550	0.0028735	0.0076366	***
NWMN	- OTHER	-0.0039443	-0.0065038	-0.0013850	***
NWMN	- MA_ZONE	0.0003355	-0.0038875	0.0045586	

NWMN	- TRACE	0.0011050	-0.0021238	0.0043338	
NWMN	- SWS	0.0013108	-0.0006688	0.0032903	
MA_ZONE	- OTHER	-0.0042798	-0.0087056	0.0001460	
MA_ZONE	- NWMN	-0.0003355	-0.0045586	0.0038875	
MA_ZONE	- TRACE	0.0007695	-0.0040744	0.0056133	
MA_ZONE	- SWS	0.0009752	-0.0031426	0.0050930	
TRACE	- OTHER	-0.0050493	-0.0085391	-0.0015595	***
TRACE	- NWMN	-0.0011050	-0.0043338	0.0021238	
TRACE	- MA_ZONE	-0.0007695	-0.0056133	0.0040744	
TRACE	- SWS	0.0002057	-0.0028841	0.0032956	
SWS	- OTHER	-0.0052550	-0.0076366	-0.0028735	***
SWS	- NWMN	-0.0013108	-0.0032903	0.0006688	
SWS	- MA_ZONE	-0.0009752	-0.0050930	0.0031426	
SWS	- TRACE	-0.0002057	-0.0032956	0.0028841	

Table 21. Model results for testing differences in CCT-susceptible rates between the minimum convex polygon strata

Source	DF	Sum of squares	Mean square	F value	Pr>F
Model	5	0.00178683	0.00035737	2.265	0.0463
Error	900	0.142062258	0.00015785		
Corrected total	905	0.14384908			

R-square	Coeff var	Root MSE	cc_sus_rate mean
0.012422	691.8996	0.012564	0.001816

Source	DF	Type III SS	Mean square	F value	Pr>F
Risk zone	5	0.00178683	0.00035737	2.26	0.0463

Table 22. Least significant differences (LSD). Pairwise differences in mean CCT reactor rates associated with all traced herds between the minimum convex polygons movement strata and their corresponding 95-percent confidence limits of the differences

(Comparisons significant at the 0.05 level are indicated by ***.)

TALL_Zone comparison	Difference between means	95% confidence limits	
90-25	0.001585	-0.001392	0.004561
90-75	0.002832	-0.000650	0.006314

90-50	0.003466	0.000537	0.006395	***
90-95	0.003841	0.000155	0.007527	***
90-0	0.004324	0.001379	0.007269	***
25-90	-0.001585	-0.004561	0.001392	
25-75	0.001247	-0.001819	0.004314	
25-50	0.001882	-0.000539	0.004302	
25-95	0.002256	-0.001040	0.005553	
25-0	0.002739	0.000300	0.005179	***
75-90	-0.002832	-0.006314	0.000650	
75-25	-0.001247	-0.004314	0.001819	
75-50	0.000634	-0.002386	0.003655	
75-95	0.001009	-0.002750	0.004768	
75-0	0.001492	-0.001544	0.004528	
50-90	-0.003466	-0.006395	-0.000537	***
50-25	-0.001882	-0.004302	0.000539	
50-75	-0.000634	-0.003655	0.002386	
50-95	0.000375	-0.002879	0.003628	
50-0	0.000858	-0.001524	0.003239	
95-90	-0.003841	-0.007527	-0.000155	***
95-25	-0.002256	-0.005553	0.001040	
95-75	-0.001009	-0.004768	0.002750	
95-50	-0.000375	-0.003628	0.002879	
95-0	0.000483	-0.002784	0.003750	
0-90	-0.004324	-0.007269	-0.001379	***
0-25	-0.002739	-0.005179	-0.000300	***
0-75	-0.001492	-0.004528	0.001544	
0-50	-0.000858	-0.003239	0.001524	
0-95	-0.000483	-0.003750	0.002784	

Appendix 3: Additional Figures

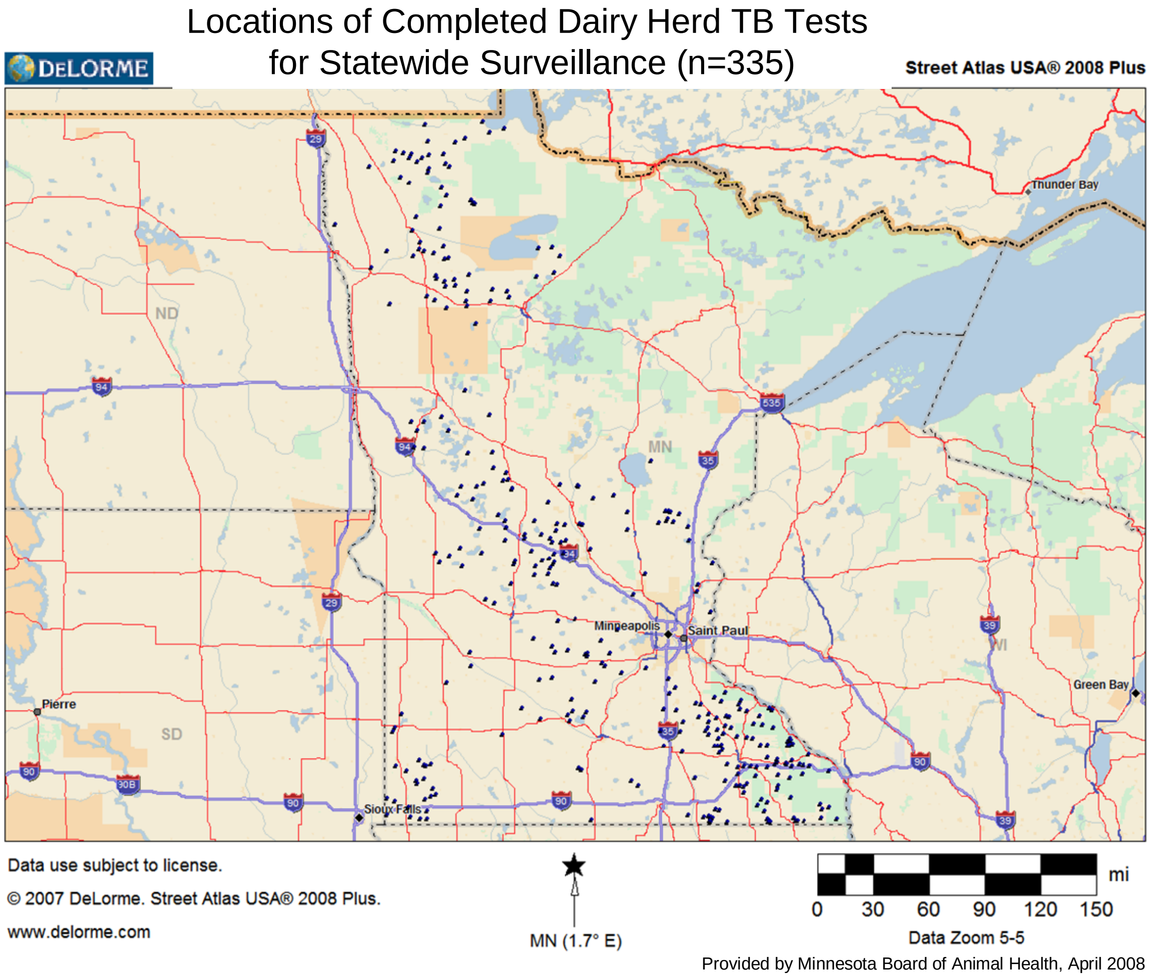


Figure 13. Location of dairies tested in Minnesota for statewide surveillance (FY 2007). (Minnesota Board of Animal Health)

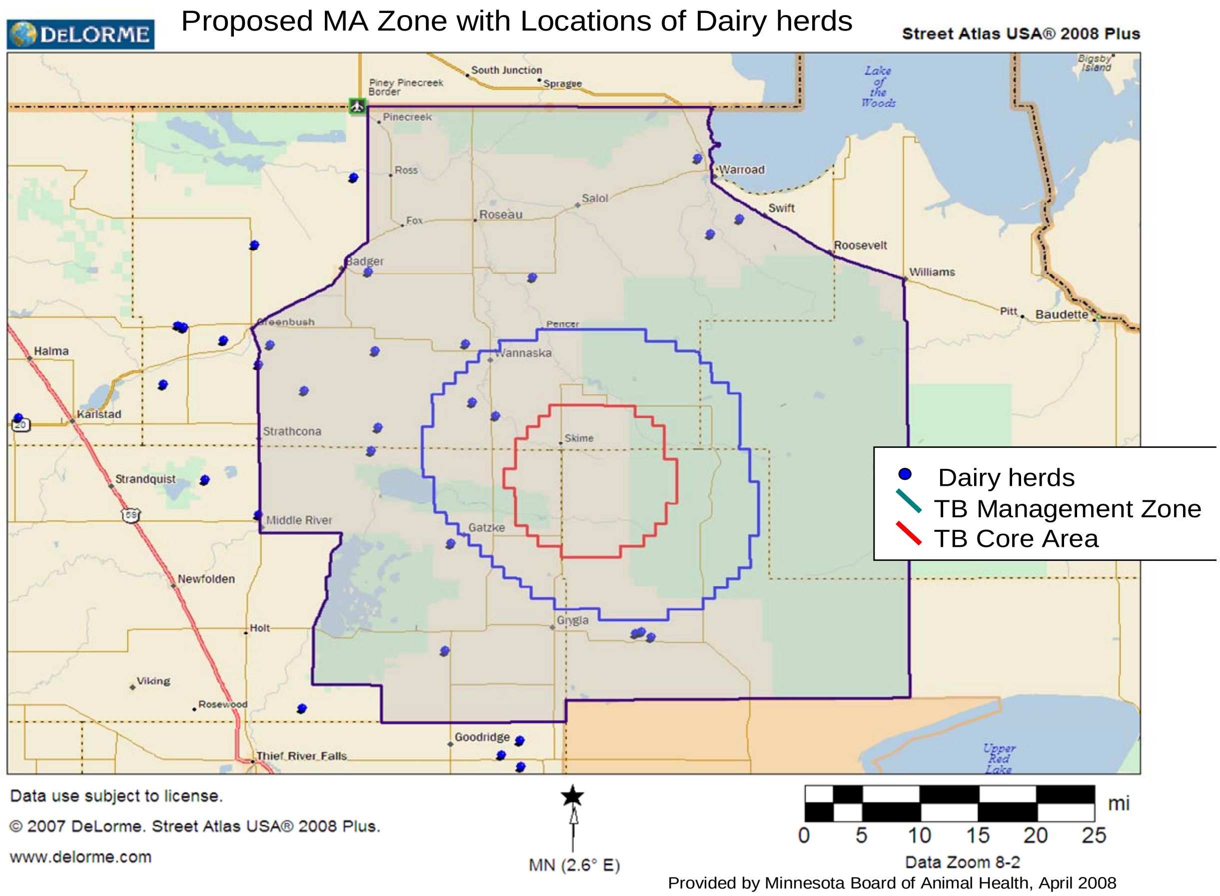


Figure 14. Dairy locations in or around the proposed MA zone. (Minnesota Board of Animal Health)

State Ranking of Caudal Fold Response Rates in domestic Bovine and Cervid Species

STATE	Number of responders	Total number tested	Caudal Fold Response Rate
RI	20	106	0.18868
CT	27	219	0.12329
NH	75	998	0.07515
SD	270	5131	0.05262
MI	87888	1992355	0.04411
NE	654	16108	0.0406
WI	315	8276	0.03806
VA	308	9101	0.03384
MN	5947	176787	0.03364
KY	33	1025	0.0322
WA	487	17650	0.02759
UT	42	1607	0.02614
NM	11577	457251	0.02532
IA	266	11322	0.02349
PR	2484	106436	0.02334
CO	112	4872	0.02299
KS	732	36451	0.02008

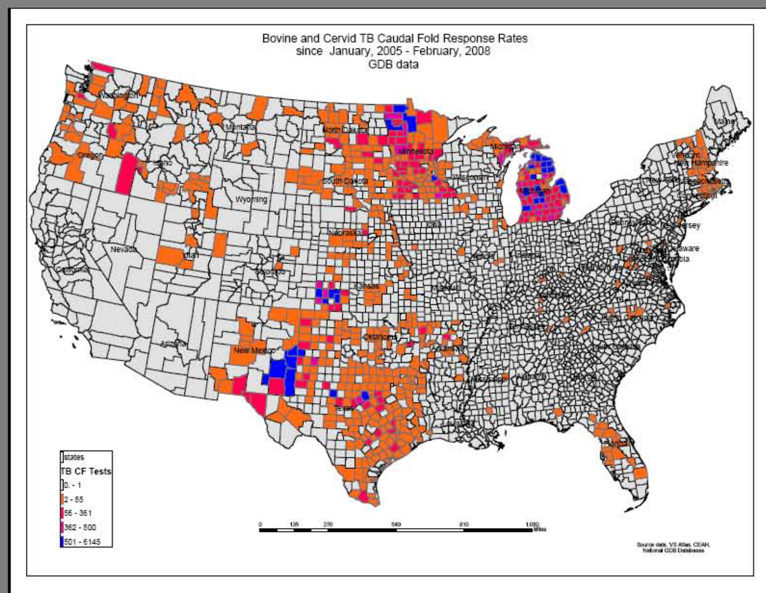


Figure 15. Reported caudal fold response rates in cattle and cervids across the United States (2005–08).

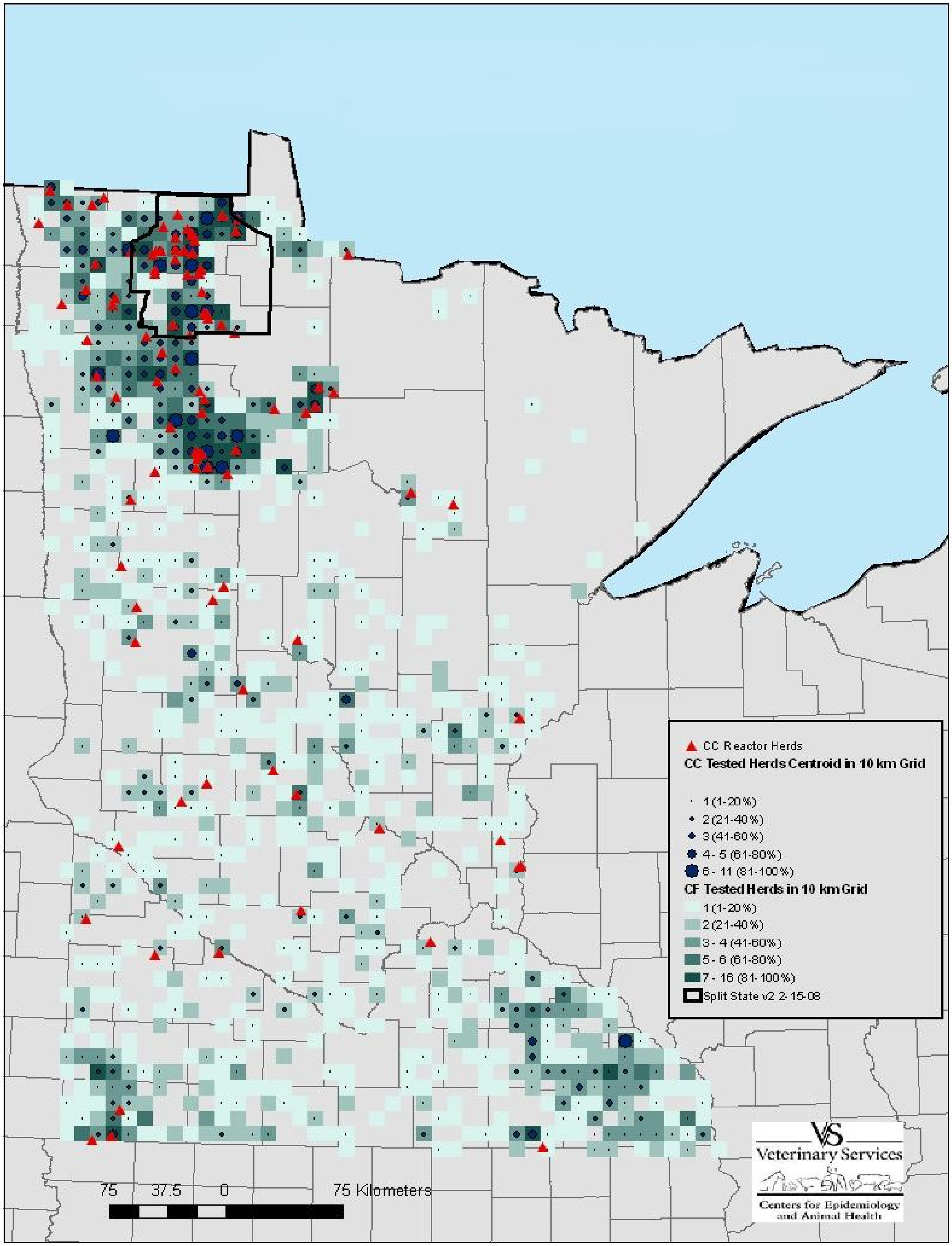


Figure 16. The location of the 1,885 whole herds that have been tested at least once from May 2005-February 2008 in Minnesota. This maps show a higher concentration of tested herds in the northern part of the State and corresponding CC reactors.

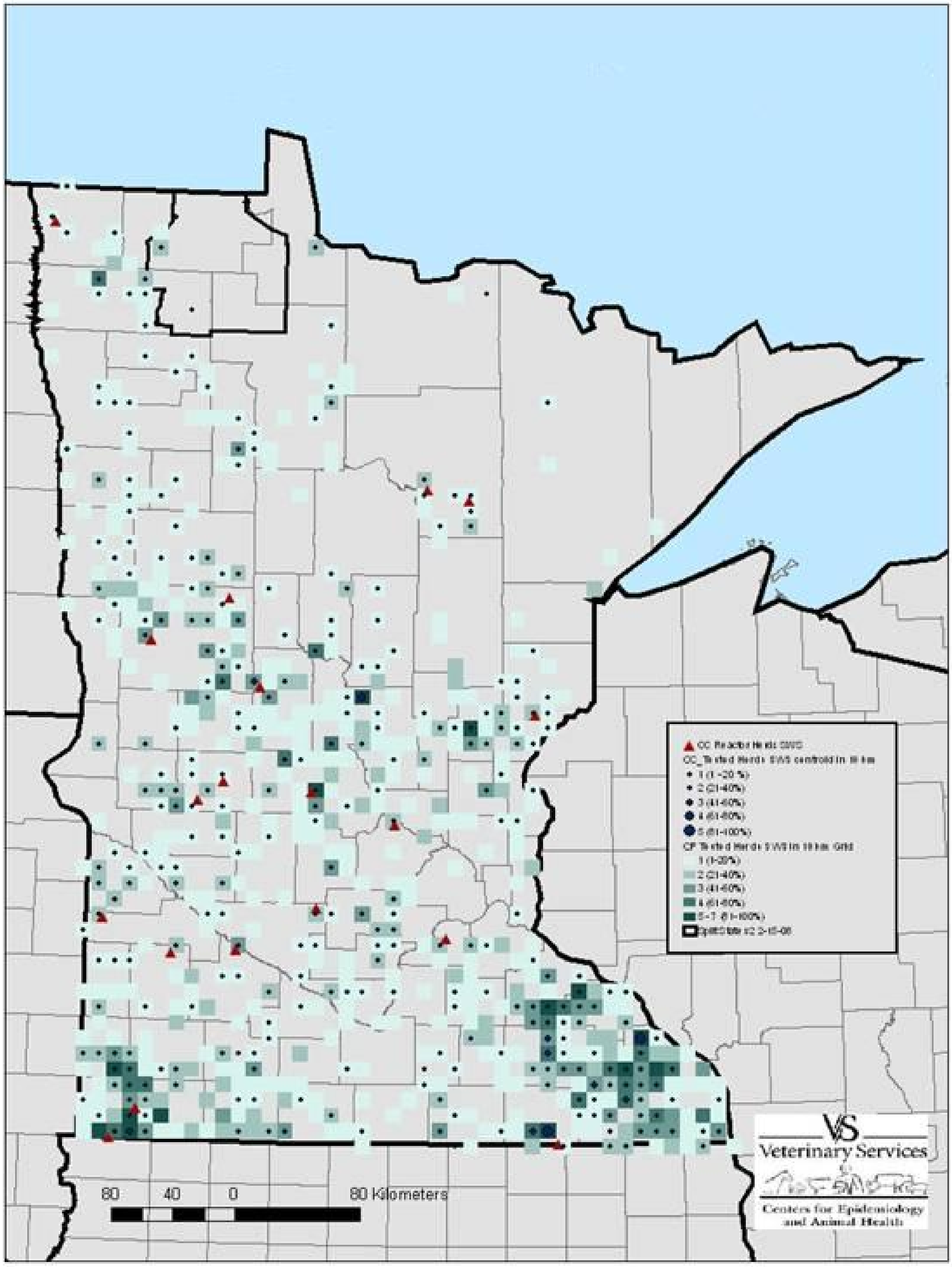


Figure 17. This map displays only those herds tested as part of the statewide surveillance efforts May 2005-February 2008.

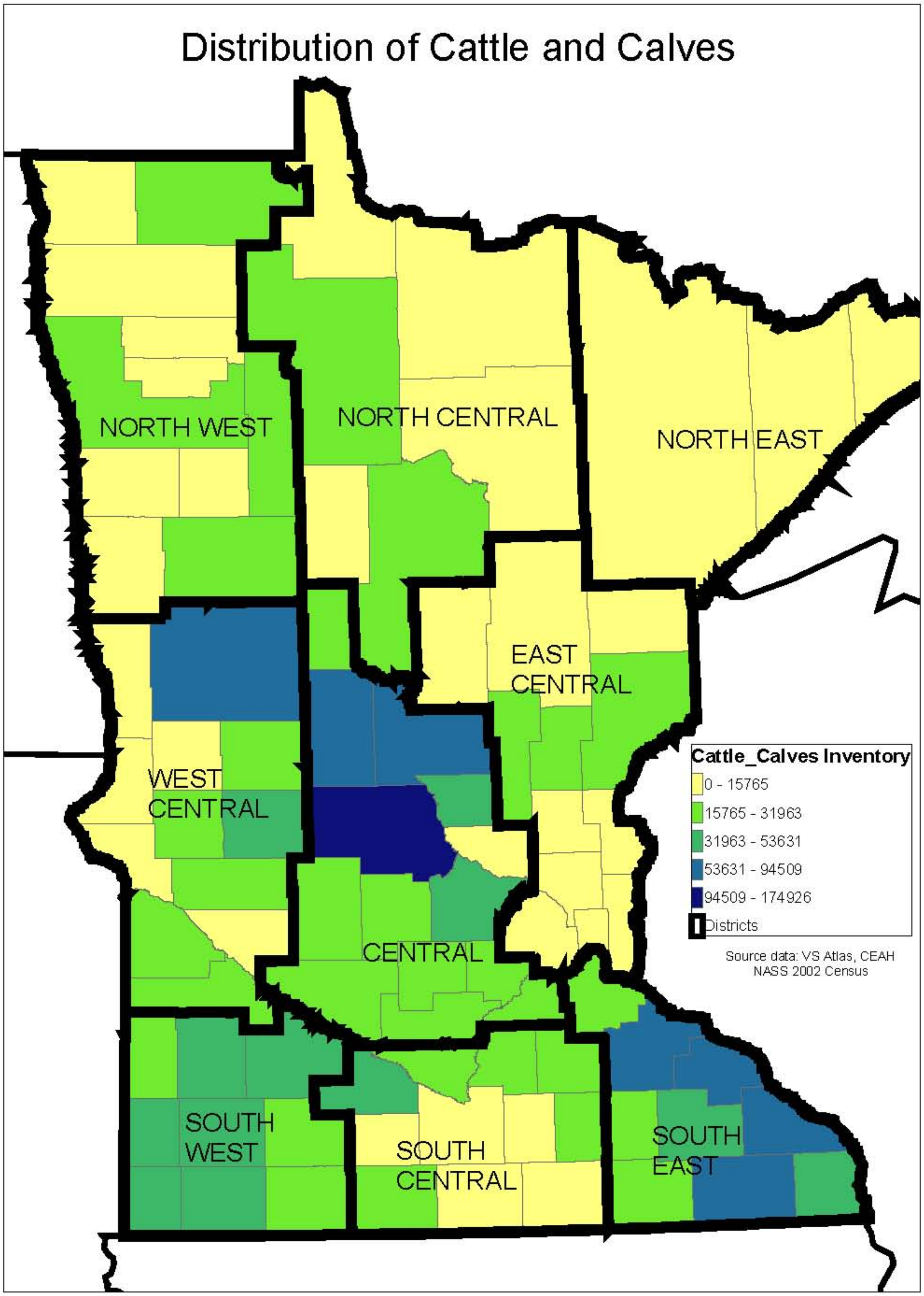


Figure 18. Distribution of cattle and calves in Minnesota.

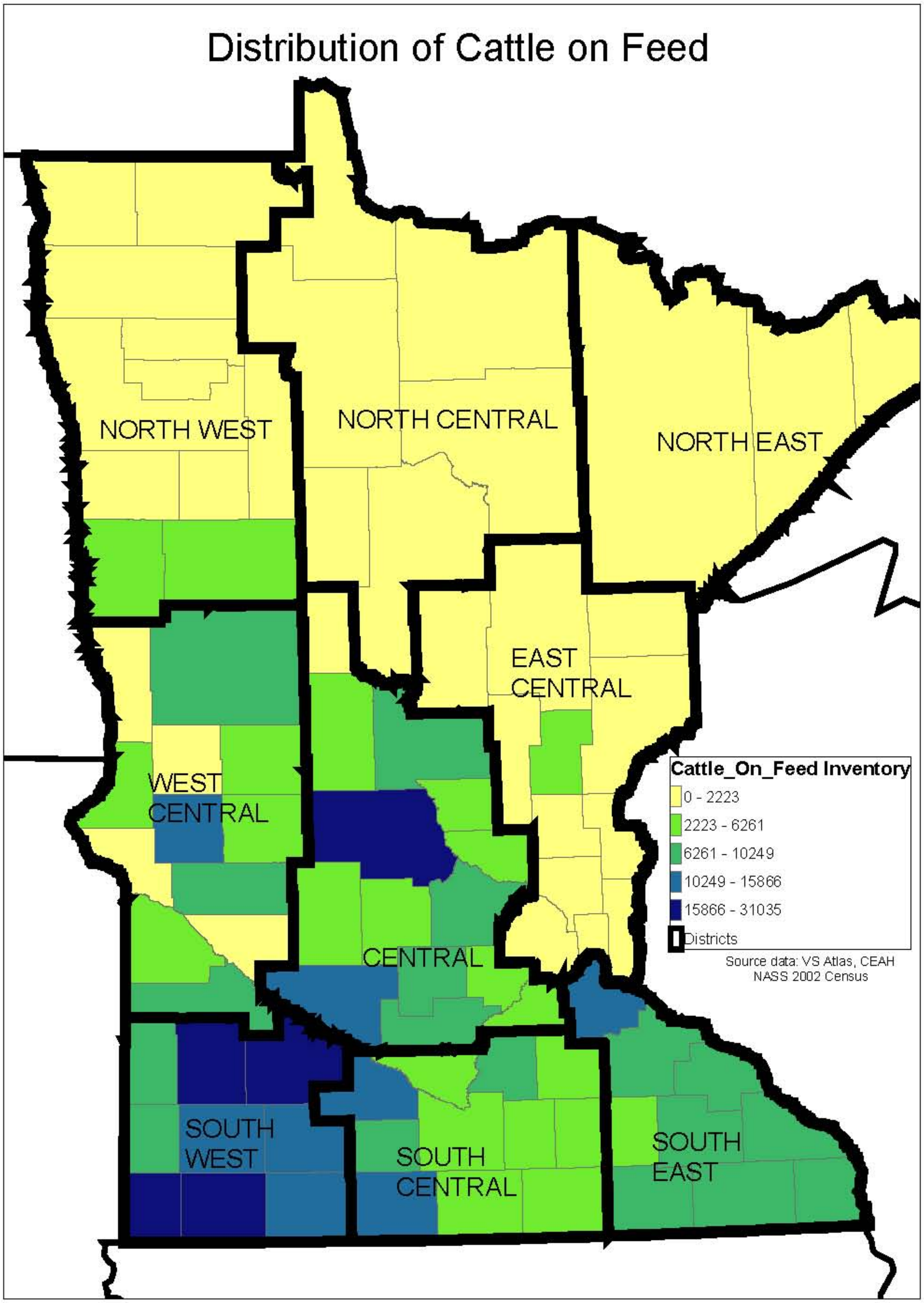


Figure 19. Distribution of cattle on feed in Minnesota.

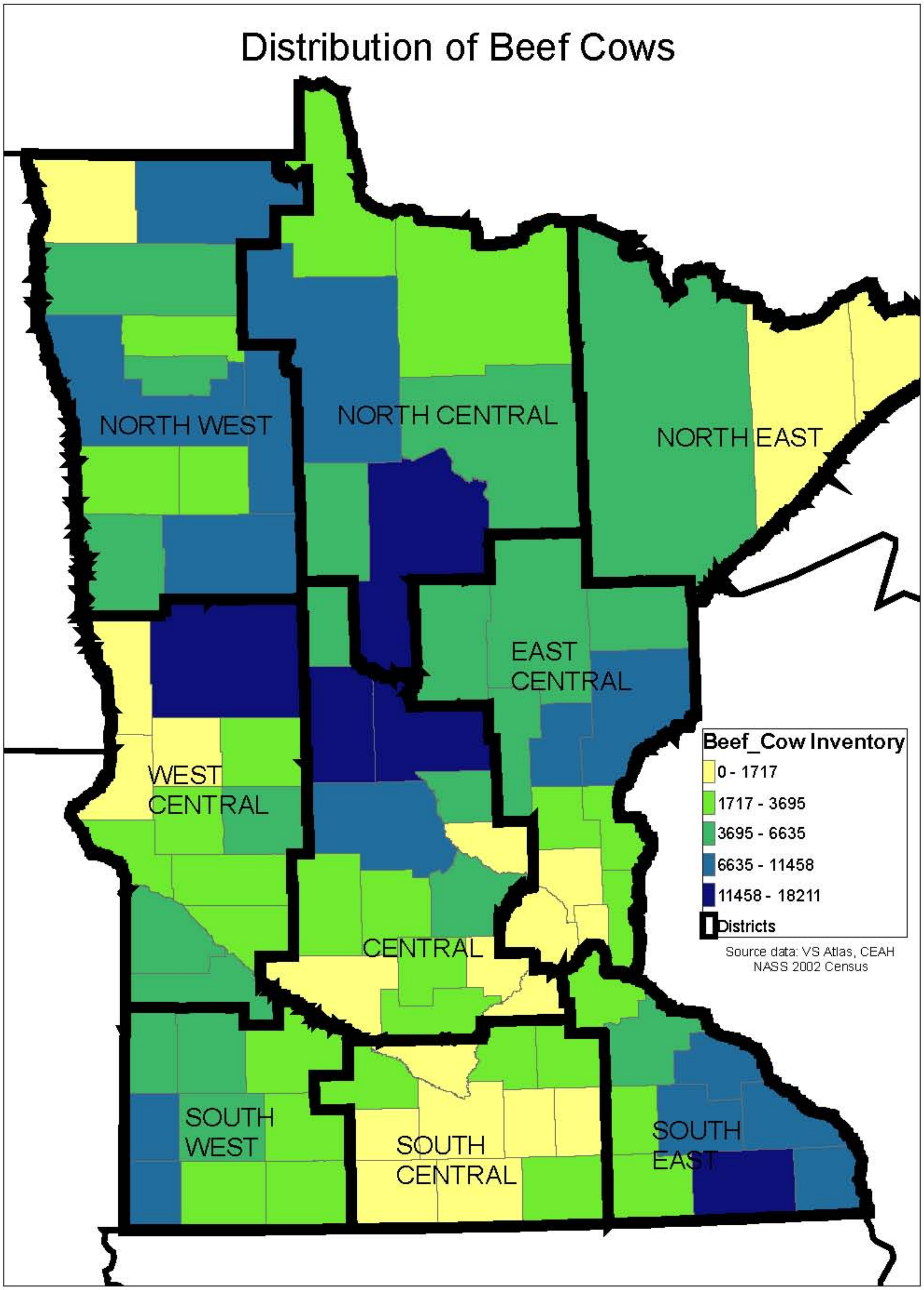


Figure 20. Distribution of beef cows in Minnesota.

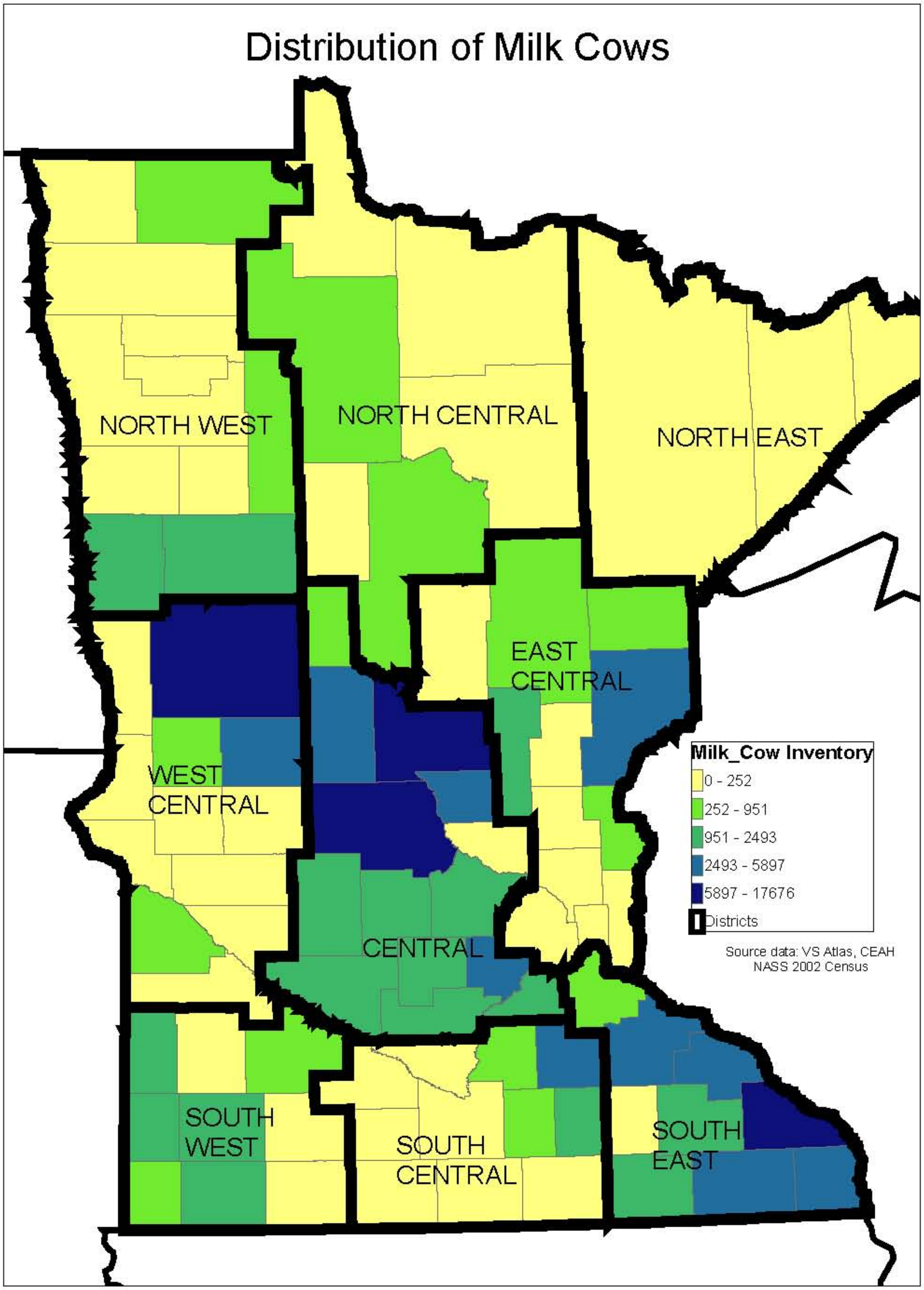


Figure 21. Distribution of milk cows in Minnesota.

Appendix 4: Description of Agriculture in Minnesota and Cost of the Proposed Split-State Plan

Minnesota agriculture

Value of agriculture industries in Minnesota

The benefit to Minnesota of split-State status is the avoidance of cost to the State of Minnesota and Minnesota cattle producers outside the proposed MA zone by attaining TB-free status. The cost of TB testing alone was estimated to be $29.1 million per year (USDA:ERS 2008). The total potential cost of the State of Minnesota remaining in MA status has not been estimated. Other costs to estimate include State and Federal personnel and resource costs associated with meeting testing and movement requirements, costs to producers associated with TB testing, and movement requirements over those costs reimbursed by the government, discounted cattle price, costs to Minnesota DNR associated with managing an infected deer or elk herd, and other direct and indirect losses to the Minnesota economy. Although these costs have not been estimated, it is likely they are at least as significant as testing costs.

Minnesota's agriculture production is a significant portion of U.S. agriculture production. In 2006, the value of Minnesota's agricultural receipts at $9.77 million accounted for 4.1 percent of total production of livestock, and products amounted to $4.6 billion or 4.2 percent of total U.S. livestock receipts. Receipts from cattle and calves at $925.5 million (or 1.9 percent of U.S. receipts from cattle and calves) ranked behind hogs at $1.75 million (or 12.4 percent of total U.S. receipts from hogs), but ahead of sheep and lambs at $13.3 million (or 2.8 percent of total U.S. receipts from sheep and lambs). Receipts from dairy products amounted to $1.07 billion or 4.6 percent of total U.S receipts from dairy products (USDA:ERS 2008).

OIE recommends import restrictions from non-TB-free countries and zones for live bovine animals, semen, and embryos as well as for live sheep and goats. Exports of live bovine animals from Minnesota amounted to $3.9 million in 2007, all of which were exports of bovine animals to Mexico and Canada (World Trade Atlas 2000-07). Exports in 2007 far exceeded those of the previous 3 years due to bovine spongiform encephalopathy (BSE) in the United States. Exports of live bovines exceeded $1 million in several years before 2003. No live bovine animals were exported from Minnesota in 2001 and 2002, and export revenues amounted to only $30,856 in 2000.

Table 23. Exports of live bovine animals from Minnesota, 1997–2007
(dollars) (no data for 2001,2002, 2004)

Country	1997	1998	1999	2000	2003	2005	2006	2007
World	1,077,140	1,028,715	329,153	30,856	1,358,671	130,473	43,998	3,902,173
Brazil			9,000					
Canada	639,940	768,615	149,143	30,856	137,658	76,473	43,998	803,653
Cuba					199,400	54,000		

Mexico	437,200	260,100	171,010		1,021,613			3,098,520

Exports of sheep and goats from Minnesota in 2007 amounted to $43,698. This was the second largest year since 1997. There was no trade in live sheep and goats for 5 of the past 10 years (table 24).

Table 24. Exports of sheep and goats from Minnesota, 1997–2007 (dollars) (no data for 2001,2002, 2004)

Country	1997	1998	1999	2000	2003	2005	2006	2007
World			8,677	30,856	125,970	15,000	25,295	43,698
Canada			8,677	30,856			25,295	43,698
Cuba						15,000		
Japan					125,970			

Exports of bovine semen ranged between $17,700 and $19,800 from 2005 to 2007. There were no exports in 2004 due to BSE in the United States. From 2000 to 2002, exports of bovine semen were high, peaking in 2002 at $1,810,000[t] (table 25).

Table 25. Exports of bovine semen from Minnesota, 1997–2007 (dollars) (no data for 2004)

Country	1997	1998	1999	2000	2001	2002	2003	2005	2006	2007
World	6,790	44,169	13,052	402,380	1,142,954	1,809,955	19,837	19,600	19,187	17,700
Argentina		17,493	7,865						7,084	
Belgium										9,200
Canada	6,790	26,676	5,187		6,866	127,385	2,587			
Japan							0	19,600		
Mexico				402,380	585,720	1,682,570	17,250			
Portugal										8,500
New Zealand									12,103	
Turkey					550,368					

<u>Trade patterns for cattle</u>

Inventory of all cattle and calves in Minnesota as of January 1, 2008, was 2.4 million head, which ranked 12th among all States in the United States. Minnesota's dairy cow inventory at 463,000 head ranked sixth among all States. Minnesota ranked 10th in number of cattle on feed at 305,000 head, while it ranked 27th in the number of beef cows at 397,000 head (USDA:NASS 2008).

[t] Bovine embryos are also exported from Minnesota, but the data are not available at this time.

Between 2004 and 2007, 1.55 million to 1.61 million Minnesota cattle were marketed per year. Of these, 460,197 to 481,990 were Minnesota cattle marketed in other States. In Minnesota, 307,955 to 333,653 cattle from other States were marketed. Of the cattle marketed in Minnesota, 85 percent were reported to the Minnesota Beef Council, which tracks marketings by type of market. Over the 4-year period, 61 percent of marketings were through auction markets. An additional 17 percent of marketings were direct to packers. Assuming the 15 percent of non-reported sales were private treaty sales, 16 percent of marketings were through private treaty. Three percent of marketings were through dealer/order buyers, and 3 percent of marketings were classified as special sales, which includes fairs and farm sales of breeding stock.

Table 26. Number of cattle marketed by market type, 2004–07

Type	2004	2005	2006	2007	Total
Auction market	898,623	855,760	865,887	857,481	3,477,750
Dealer/order buyer	38,707	34,715	40,848	35,193	149,463
Feedlot	--	76	--	351	427
Private treaty	13,848	14,889	14,042	14,154	56,933
Packer/processor	224,782	216,471	249,173	280,676	971,100
Special sales	15,274	69,408	35,906	52,706	173,294
Marketings not reported to MN Beef Council	210,218	210,233	212,798	218,922	852,171
Cattle marketed in MN	**1,401,451**	**1,401,551**	**1,418,654**	**1,459,483**	**5,681,138**
Out-of-State cattle marketed in MN	309,493	312,052	307,955	333,653	1,263,153
MN cattle marketed out-of-State	481,990	460,217	460,197	479,903	1,882,307
MN cattle marketed	**1,573,948**	**1,549,716**	**1,570,896**	**1,605,733**	**6,300,292**

Source: Minnesota Beef Council.

Twenty-two percent of cattle marketed in Minnesota came from 21 other States. Eighty-two percent of these cattle came from the surrounding States of Iowa, Nebraska, South Dakota, and Wisconsin (table 30).

Although data are not collected on the disposition of cattle coming into Minnesota, it is possible to make general statements about the disposition of these cattle. Cattle from Illinois, Iowa, Nebraska, North Dakota, and South Dakota are likely to have been either feeder cattle or fed cattle for slaughter. Cattle from Colorado, Idaho, Kansas, and Texas are likely to have been feeder cattle or replacement beef heifers. Cattle from Michigan, Pennsylvania, and Wisconsin are likely to have been replacement dairy heifers or cull cows.

Thirty percent of Minnesota cattle were marketed in other States. Eighty-two percent of these marketings were in the same four surrounding States.

Although data on the disposition of Minnesota cattle marketed outside the State are not collected, general statements about the disposition of these cattle can be made. Cattle going to Illinois, Iowa, Nebraska, and South Dakota are likely to have been fed cattle for slaughter or feeder cattle. Cattle going to Kansas, Missouri, North Dakota, and Texas are likely to have been feeder cattle. Cattle going to Wisconsin were likely to have been replacement dairy heifers or cull cows.

Between 2004 and 2007, total slaughter in Minnesota ranged from 644,000 to 765,800 head per year. Four percent of total slaughter occurred in State-inspected plants. Of the federally-inspected slaughter, 74 percent was accounted for by cows, bulls, and stags. Ninety-nine percent of Minnesota's slaughter was accounted for by the three largest packers. Thirty-eight percent of total slaughter in Minnesota was from Minnesota cattle. This figure was 28 percent for cows, bulls, and stags; and 55 percent for steers and heifers.[u]

Table 27. Minnesota cattle slaughtered by class, 2004–07 (head x1,000)

Type	2004	2005	2006	2007	Total
Steers	101.9	95.0	126.9	142.1	465.9
Heifers	47.2	50.3	69.2	74.5	241.2
Beef cows	310.7	318.6	363.5	395.2	1,388.0
Dairy cows	156.8	97.0	77.7	70.4	401.9
Bulls/stags	55.9	54.3	59.2	55.7	225.1
Federally inspected slaughter	672.4	615.3	696.4	737.9	2,722.0
State-inspected slaughter	28.7	28.7	28.3	27.9	113.6
Total slaughter	**701.1**	**644.0**	**724.7**	**765.8**	**2,835.6**

Source: Federally inspected slaughter by class from FSIS. Total slaughter from USDA:NASS, Livestock slaughter summary for 2004–07.

Value of livestock and agriculture in the proposed MA zone

The four counties affected by the Minnesota split-State status application represent a small percentage of Minnesota's agriculture production. Beltrami, Marshall, Lake of the Woods, and Roseau Counties account for 2.0 percent of Minnesota's total agricultural receipts, and Marshall County alone accounts for 1.3 percent of the total (USDA:NASS 2004). The four counties account for 7.3 percent of beef cow numbers in Minnesota, 0.9 percent of milk cow numbers, and 2.3 percent of sheep numbers. No cattle feeding or hog production operations are listed for the four counties (USDA:ERS 2008).

Within the four counties, agricultural production and processing ranked third in industry output and employment. Of the $424.4 million and 5,271 jobs coming from agricultural production in 2006, $47.2 million and 1,302 jobs were accounted for by cattle and dairy farming (Ye 2008).

[u] Assumes all State-inspected and small Federally-inspected plants slaughter only Minnesota cattle. Figures for larger plants from Curt Zimmerman, Minnesota Department of Agriculture, pers. comm. with various packers.

Only small portions of each of these counties are included in the proposed MA zone, and the topography of the proposed MA zone can be characterized as flat country with serious drainage problems. Much of the land in the proposed MA zone is woods and pasture. The portions of the four counties included in the proposed MA zone are part of the Northern Minnesota Wetlands ecoregion. The ecoregion is very flat and is made up primarily of wetlands, peat bogs, and marshes. Extensive networks of drainage ditches drain large areas of the ecoregion. Agriculture in the area is limited by the predominance of wet peatlands. Some small grains are grown with the major agricultural use being for livestock and hay (Minnesota Pollution Control Agency 2008a). Thirty-three percent of cow/calf operations in the four counties (281 of the 860 farms with beef cows) are located in the proposed MA zone. Twenty-two percent of dairies in the four counties (19 of the 85 farms with milk cows) are located in the proposed MA zone. In addition, there are eight farms with goats and one farm with captive cervids in the zone (USDA:NASS 2004; Hartmann 2008).

Hay is important in livestock production, and is a possible pathway for spread of bovine TB. In 2006, 5.7 million tons of hay with a value $136 million were produced in Minnesota. Beltrami, Lake of the Woods, Marshall, and Roseau Counties accounted for 4.7 percent of Minnesota's hay production. The value of the 265,500 tons of hay produced in the four counties was approximately $6.4 million[v] (USDA:NASS 2004; Minnesota Department of Agriculture 2007; USDA:ERS 2008).

Value of deer hunting

There were 270,778 deer harvested in the State of Minnesota in 2006. Twelve percent (33,225) were harvested in the four counties in the proposed MA zone. The number of deer hunters who hunted deer in the four counties numbered 49,312. Of these, 20,881 resided in the four counties. Retail expenditures by deer hunters in the four counties amounted to $31.3 million. Salaries, wages, and business owners' income from deer hunters amounted to $18 million (Minnesota Department of Natural Resources 2008).

Table 28. Minnesota—leading commodities for cash receipts, 2006

		Value of receipts ($1,000)	**Percent of U.S. value**	**Value of U.S. receipts** ($1,000)
	All commodities	9,769,512	4.1	239,271,907
	Livestock and products	4,641,925	3.9	119,320,429
	Crops	5,127,587	4.3	119,951,478
Rank	**Items**			
1	Corn	2,029,081	9.3	21,716,106
2	Hogs	1,751,000	12.4	14,085,345
3	Soybeans	1,676,210	9.9	16,920,732

[v] This is assuming the value of hay in the four counties is proportional to production of hay in the four counties.

4	Dairy products	1,073,670	4.6	23,421,987
5	Cattle and calves	925,531	1.9	49,148,366
6	Turkeys	568,935	16.3	3,482,746
7	Sugar beets	411,019	34.4	1,193,151
8	Wheat	300,816	4.1	7,317,737
9	Greenhouse/nursery	200,400	1.2	16,891,934
10	Hay	135,995	2.8	4,912,144
11	Potatoes	107,889	3.7	2,929,648
12	Chicken eggs	107,303	2.5	4,340,076
13	Broilers	87,210	0.5	18,851,949
14	Corn, sweet	64,904	7.9	825,101
15	Dry beans	49,472	9.7	512,084
16	Peas, green	39,924	40.1	99,597
17	Sunflower	27,945	6.9	403,123
18	Sheep and lambs	13,297	2.8	473,435
19	Honey	8,900	5.5	161,314
20	Apples	8,847	0.4	2,100,310
21	Oats	8,708	8.9	97,661
22	Barley	7,023	1.5	469,010
23	Carrots	1,940	0.3	576,760

Table 29. Number of cattle shipped to various States from Minnesota, 2004–07

State	2004	2005	2006	2007	Total
Alabama	-	-	-	102	102
Arizona	1	5	-	-	6
Arkansas	602	681	333	207	1,823
California	12	48	241	1	302
Colorado	1,635	-	124	49	1,808
Florida	120	101	30	-	251
Georgia	13	-	-	-	13
Idaho	816	69	1,141	2	2,028
Illinois	8,381	4,164	3,316	383	16,244
Indiana	8,049	6,195	8,787	4,732	27,763
Iowa	99,599	69,168	85,346	104,509	358,622
Kansas	2,561	3,178	2,491	2,573	10,803
Kentucky	946	195	977	523	2,641
Louisiana	501	43	-	2	546
Maine	151	-	-	-	151
Michigan	386	441	210	137	1,174
Mississippi	560	569	359	11	1,499
Missouri	2,516	1,714	4,655	6,450	15,335

Montana	2,363	1,153	5,388	7,654	16,558
Nebraska	24,746	10,427	13,477	27,114	75,764
New Mexico	-	65	141	2	208
New York	191	130	-	3	324
North Carolina	-	-	195	1,517	1,712
North Dakota	12,105	11,793	14,540	15,953	54,391
Ohio	789	255	237	1,076	2,357
Oklahoma	3,574	263	1,376	2,869	8,082
Oregon	-	-	69	-	69
Pennsylvania	1,007	1,529	2,651	710	5,897
South Dakota	43,211	32,020	62,785	67,539	205,555
Tennessee	38	2	33	90	163
Texas	10,885	2,897	3,297	3,780	20,859
Utah	-	-	131	3	134
Vermont	-	1	2	-	3
Virginia	5,641	4,498	3,604	5,300	19,043
Washington	1	-	-	5	6
West Virginia	-	71	42	-	113
Wisconsin	111,372	73,420	90,688	83,834	359,314
Wyoming	500	132	48	805	1,485
Total	**343,272**	**225,227**	**306,714**	**337,935**	**1,213,148**

Table 30. Number of cattle shipped from various States to Minnesota, 2004–07

State	2004	2005	2006	2007	Total
California	526	-	-	7	533
Colorado	8,980	9,044	11,322	4,326	33,672
Idaho	1,448	-	-	-	1,448
Illinois	8,479	8,760	9,563	8,953	35,755
Iowa	64,741	48,501	58,871	51,236	223,349
Kansas	31,357	37,620	17,966	31,112	118,055
Kentucky	4,195	3,388	5,029	3,249	15,861
Maine	-	-	83	-	83
Massachusetts	3	-	-	-	3
Michigan	9,318	6,223	7,397	5,465	28,403
Missouri	112	113	386	57	668
Nebraska	180,485	146,975	184,395	178,910	690,765
New York	-	99	-	-	99
North Dakota	14,133	7,163	6,089	3,254	30,639
Ohio	70	2	14	40	126
Oklahoma	41	-	-	168	209
Pennsylvania	9,233	8,352	10,029	9,866	37,480

South Dakota	83,165	55,522	75,427	68,375	282,489
Texas	137	39	4	9,781	9,961
Virginia	54	27	-	-	81
Wisconsin	79,965	40,412	62,473	89,971	272,821
Total	**496,442**	**372,240**	**449,048**	**464,890**	**1,782,620**

Table 31. Top ten counties in Minnesota by cattle industry segment, 2007

Segment	1	2	3	4	5	6	7	8	9	10
Cattle and calves	Stearns	Otter Tail	Morrison	Winona	Fillmore	Goodhue	Todd	Wabasha	Rock	Houston
Beef cows	Fillmore	Otter Tail	Morrison	Todd	Cass	Beltarmi	Stearns	Houston	Clearwater	Olmsted
Milk cows	Stearns	Morrison	Winona	Otter Tail	Goodhue	Wabasha	Todd	Stevens	Fillmore	Benton
Cattle on feed	Rock	Nobles	Lyon	Renville	Redwood	Cottonwood	Stearns	Murray	Dakota	Brown

Source: 2007 Minnesota Agricultural Statistics.

Cost of the current Minnesota plan for split-State status

The cost of split-State status will be shared among several entities. Those entities directly bearing costs include the Federal government through USDA:APHIS; the State of Minnesota; cattle producers in the proposed MA zone; and cattle producers in the proposed AF zone. Other entities potentially bearing costs include residents of the four counties surrounding the proposed MA zone and Minnesota deer hunters.

Cost and funding for USDA:APHIS

Through a cooperative agreement between USDA:APHIS and the State of Minnesota, USDA:APHIS will provide support in terms of veterinarian personnel, money to be applied to indemnity and depopulation costs, and $814,519 for the State to apply to its budget over the 24-month agreement (Healey 2008).

Cost to the State of Minnesota

The Minnesota BAH has developed a 10-year budget for the cost of implementing the plan. Present value of the budget is $20,371,620[w] over 10 years ($27,161,842 in nominal terms).

The budget addresses personnel and resource use to accomplish testing and identification of cattle and herds in the proposed MA zone, surveillance of cattle herds in the proposed AF zone, imposing movement controls in and out of the proposed MA zone, tracing potentially infected cattle, and indemnifying cattle producers in the event of herd depopulation.

One of the assumptions underlying the budget is that eradication of bovine TB will take 6 to 7 years. Personnel and resource use will be relatively high over this period. Other infected herds may be found, so costs associated with trace-out testing, indemnity, and depopulation are included.

It is assumed that after eradication, it will take an additional 3 years of testing to meet the requirements for TB-free status. Costs associated with surveillance both in the proposed MA zone and in the proposed AF zone are included. Reduced needs for personnel and resources are reflected in the budget.

Table 32. Projected 10-year budget, Minnesota Board of Animal Health

Plan fiscal year		**Expected yearly cost** (dollars)	**Discount factors**	**Present value of costs** (dollars)
2008	1	4,103,055	0.9346	3,834,631
2009	2	4,638,505	0.8734	4,051,450
2010	3	2,978,480	0.8163	2,431,327
2011	4	2,920,980	0.7629	2,228,402
2012	5	2,874,580	0.7130	2,049,536

[w] Net Present Value was determined using procedures outlined in Office of Management and Budget, Circular No. A-94 Revised.

2013	6	2,860,580	0.6663	1,906,125
2014	7	2,221,339	0.6227	1,383,338
2015	8	1,526,441	0.5820	888,403
2016	9	1,520,441	0.5439	827,019
2017	10	1,517,441	0.5083	771,390
Total		**27,161,842**		**20,371,620**

Source: Minnesota Board of Animal Health.

Minnesota herd buyout plan

The State of Minnesota's cattle herd buyout program consists of a cash payment of $500 per head in addition to any sales value the cattle owner may receive from packers or processors under conditions that:

- The cattle owner accept the offer by July 15, 2008;
- Cattle that are at least 1 year old be slaughtered by January 31, 2009;
- Cattle that are less than 1 year old be either slaughtered or moved out of the Management Area under restrictions by January 31, 2009; and
- The landowner and cattle owner will not allow any livestock to be located on land in the MA zone.

Furthermore, a cattle owner who signed the buyout contract or a cattle owner who depopulated an infected herd will receive a payment of $75 each year per animal slaughtered. No livestock will be allowed to move into the management area after the effective date of the legislation. The program will continue until the proposed MA zone's TB-free status is reinstated.

The Minnesota BAH will conduct a risk assessment for cattle herds remaining in the management area. If BAH determines that cattle herds in the management area present a risk of interaction between cattle and deer or elk, it will require the cattle owner to keep all cattle in a manner that does not allow cattle and deer or elk to interface. The BAH will also require producers who store forage crops within the management area to prevent access to the stored feedstuffs by deer or elk.

The BAH will provide cost-share assistance to producers required to fence stored forage crops or fence cattle in areas where it determines that there is an unacceptable risk of transmitting bovine TB to deer or elk. The level of assistance is 90 percent of the cost of an approved fence up to a maximum of $75,000. The BAH will establish specifications for fences and will require that they be maintained.

Cost to Minnesota DNR

HF No. 4075 also addresses controlling bovine TB in wildlife. It gives the Minnesota DNR the authority to restrict wildlife feeding within the proposed MA zone, and to remove deer and elk from the proposed MA zone. Removal of deer and elk will be done when requested by BAH. Consequently, a yearly budget for DNR activities has not been estimated.

Cost to cattle producers in the proposed MA zone

In addition to costs borne by the State of Minnesota and USDA:APHIS, producers in the proposed MA zone will bear certain costs. These costs include:

- Cost in terms of time and equipment to carry out testing requirements. Time includes the labor to round up and process cattle for testing and the time for the required record keeping.

- Price discounts for cull cows and bulls. Packers have been reluctant to accept suspects, reactors, and herds for depopulation. These packers supply ground beef products to customers who do not allow such cattle to be used.

- Price discounts for feeder cattle. Feedlot operators may consider feeder cattle from the proposed MA zone to pose a risk. Should a source herd for feeder cattle become infected, a feedlot may be subject to procedures in TB-affected feedlots as delineated in the UM&R (USDA:APHIS 2005). These measures include sending affected cattle directly to slaughter, cleaning and disinfecting pens, and not restocking affected pens for 30 days.

- Fencing costs. The Minnesota herd buyout program requires BAH to conduct a risk assessment of all cattle operations in the management area with respect to the potential for spread between cattle and wildlife. Mitigations including fencing may be required. The State will reimburse the producer for 90 percent of the initial cost of fencing up to $75,000. The producer is responsible for 10 percent of fencing costs up to $75,000 and anything over $75,000. In addition, the producer is responsible for maintaining the fencing until the proposed MA zone attains TB-free status.

- Land values. Restrictions on land use and/or returns to cattle producers can affect land values in the proposed MA zone.

None of the factors outlined above have been estimated for the region. However, it is likely the cost associated with these factors will be significant. The University of Minnesota Beef Team has developed a presentation outlining alternative marketing strategies for cattle producers in the proposed MA zone (DiCostanzo 2008).

- Alternative 1: Sale at weaning (current practice). The Beef Team estimates the additional cost to producers to comply with requirements for testing and animal identification will be between $10 and $20 per calf. There are restrictions on moving intact heifers to feedlots, and the Beef Team estimates the cost of spaying heifers to be $10 per heifer.

- Alternative 2: Sale after backgrounding.[x] Under this alternative, cattle producers would bear costs related to TB program requirements. The Beef Team describes an

[x] Backgrounding refers to the process of conditioning feeder cattle before they go into feedlots.

alternative marketing approach whereby weaned calves would be fed from weaning weights of 500 lb to between 700 and 850 lb, vaccinated, and dewormed. Costs for this alternative are estimated to be $45 to $50 per head for health and TB procedures plus $2 per day in feeding costs. Backgrounding could occur in current winter feeding areas or on approved winter grazing land.

- Alternative 3: Sale after finished. Under this alternative, cattle producers would background calves and finish them to slaughter weights in a feedlot located in the proposed MA zone. The cost to finish cattle was not estimated. Instead, an estimate was made of the amount of money available to feed cattle and break even with Alternative 1.

Alternative 3 depends on the existence of feedlots in the proposed MA zone. There are currently no functioning feedlots in the proposed MA zone; however, there is a total of 273 feedlots registered with the Minnesota Pollution Control Agency (MPCA) in Beltrami, Marshall, Roseau, and Lake of the Woods Counties (Minnesota Pollution Control Agency 2008b). It is assumed that a feedlot site registered with MPCA can be activated as a feedlot with no further permitting required (Minnesota Department of Agriculture 2006).

The purpose of the Beef Team's presentation is to inform cattle producers in the proposed MA zone of these alternatives. This presentation does not encompass all the financial considerations relevant to producers' decisions. Other factors to consider are potential for alternative enterprises, potential for alternative income, producer's age, and tax considerations, to name a few.

A factor each producer must consider and one that is of considerable interest to the State of Minnesota is whether or not to participate in the State's herd buyout program. As of May 1, 2008, the participation rate in the State's herd buyout program had not been estimated because producers had not had time to evaluate the variables upon which they will base their decisions. The participation rate in this program is a fundamental determinant of the State's cost to maintain the proposed MA zone.

Funding for the Minnesota budget

There are three sources of funding for Minnesota's budget.

One source of funding is from USDA in the form of CCC funds. This $814,519 comes from the Cooperative Agreement line item in the USDA:APHIS budget as discussed above.

A second source of funding is from HF No. 4075. This legislation calls for a $1 per head assessment (checkoff) on all cattle traded in Minnesota in 2009 except for cattle from operations located in the proposed MA zone. This money is to be collected by the Minnesota Department of Agriculture and transferred to BAH for its bovine TB control activities. BAH estimates this amount to be $1,221,000.

The third funding source is an additional $472,000 for 2008 and $2,172,000[y] for 2009, appropriated to the BAH from a general fund through HF No. 4075, which calls for activities to comply with Federal regulations under the USDA MA status. A one-time appropriation of $3,350,000 is made to BAH to fund the herd buyout plan.

Present value of funding for the State of Minnesota plan over the 10-year period is $18,435,961 ($25,422,142 in nominal terms). Assuming that BAH activities for 2008 have been funded in previous legislation and that the legislature will continue to fund the program at current levels, funding will match expected costs for the 10-year plan.

Table 33. Sources of funding for Minnesota's budget

Plan year	CCC funding (dollars)	Checkoff estimate (dollars)	State funding (dollars)	Expected yearly funding (dollars)	Discount factors	Present value of funding (dollars)
2008	831,142[z]	0	472,000	1,303,142	0.9346	1,217,890
2009	0	1,221,000	5,522,000	6,743,000	0.8734	5,889,597
2010	0	0	2,172,000	2,172,000	0.8163	1,772,999
2011	0	0	2,172,000	2,172,000	0.7629	1,657,008
2012	0	0	2,172,000	2,172,000	0.7130	1,548,606
2013	0	0	2,172,000	2,172,000	0.6663	1,447,295
2014	0	0	2,172,000	2,172,000	0.6227	1,352,612
2015	0	0	2,172,000	2,172,000	0.5820	1,264,124
2016	0	0	2,172,000	2,172,000	0.5439	1,181,424
2017	0	0	2,172,000	2,172,000	0.5083	1,104,135
Total	831,142	1,221,000	23,370,000	25,422,142		18,435,691

Source: Minnesota Board of Animal Health.

[y] HF No. 4075 calls for $2,172,000, but BAH has $2,252,000 in its budget. They are counting the $80,000 designated to the University of Minnesota for research into best practices. BAH is counting on this every year. Legislation goes through 2009.
[z] Can be used by the State of Minnesota in 2008 or 2009.

Appendix 5: Minnesota Proposed Split-State Plan

Provided by Minnesota Board of Animal Health
Minnesota Split-State Plan
Draft updated - 3/11/2008

Background

In July 2005, the Minnesota BAH and USDA discovered a beef cattle herd in Roseau County infected with bovine TB. This was the first positive herd identified in Minnesota since 1971, when the State was declared free from TB. Since then, Minnesota has identified 10 TB-infected herds (red pins on map below), all within a 72.4-km (45.0-mi) area of northwest Minnesota in Roseau and north Beltrami Counties. The Minnesota DNR has conducted surveillance for bovine TB in free-ranging white-tailed deer since 2005 and has identified 17 TB-infected deer (blue pins on map below), all within a 362.6-sq km (140.0-sq mi) area around the town of Skime.

A TB Management Plan to eliminate TB from livestock and free-ranging deer populations in Minnesota was developed by the Board, USDA, the Minnesota Department of Agriculture, and DNR with the input of industry and producer groups. In this plan, a core area of concern related to TB-infected deer was defined and the DNR is working aggressively to reduce the deer population in this area. Movement restrictions, regular TB testing, and management practices for cattle herds were also implemented in this area to assure that no TB-infected cattle leave the area and cattle/deer interactions are minimized. This plan also includes conducting statewide surveillance in both cattle and free-ranging deer populations of Minnesota to demonstrate the absence of TB in the rest of the State. During the 2006 fall hunting season, 1,000 deer from the Intensive Surveillance zone and 4,000 deer from the rest of the State were collected and tested for bovine TB; no TB-infected deer were found outside the core area of northwest Minnesota. Statewide TB testing of more than 1,550 beef and dairy herds over the last year and a half found no infected cattle herds outside the small geographic area of northwest Minnesota. Ongoing program activities include:

1. As of July 1, 2006, all veterinarians must be certified by the BAH after additional training to TB test cattle and bison. Over 450 Minnesota-licensed veterinarians have received this training which meets the criteria of a USDA Designated Accredited veterinarian.

2. All cattle, bison, and captive cervidae herds within 16.1 km (10 mi) of a TB-infected cattle herd or TB-infected deer collection location are tested for TB (referred to as Area testing).

3. All animals sold out of an infected herd are considered Exposed animals and are traced. If they are found alive they are indemnified and killed. Samples are collected from all animals for TB diagnostic evaluation.

4. All herds identified as a trace-in or trace-out to an infected herd are tested by regulatory veterinarians. Trace-out herds that have had an exposed animal in the herd within the last 4 years are tested twice, 1 year apart.

5. Since fall 2005, the DNR has sampled deer collected during the hunting season from locations within 24.1 km (15 mi) of an infected cattle farm. Over 3,000 deer collected from these areas have included 17 TB-infected deer.

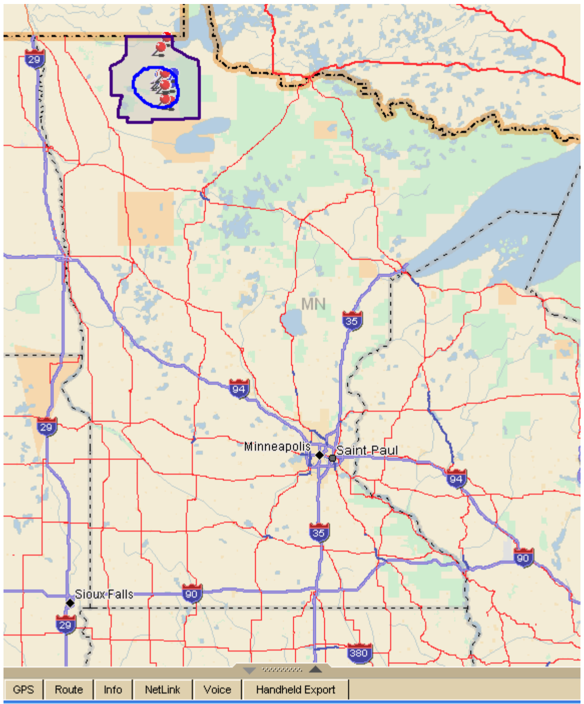
6. The DNR defined a TB core area after the 2006 hunting season based on the TB-infected deer found in 2005 and 2006. The TB core area includes all TB-infected deer with a minimum 3.2-km (2.0-mi) radius around all infected deer. They also defined a TB management zone based on a 16.1-km (10.0-mi) radius around all infected deer. The DNR has outlined a multipronged approach to deer population reduction in this area which includes:
    a. A special TB permit hunting zone with liberalized hunting seasons and permits;
    b. Landowner permits for hunting;
    c. A recreational feed ban in a 10,360-sq km (4,000-sq mi) area around these areas; and
    d. Contracting with USDA:WS for targeted herd reduction in late winter and early spring.

7. In June 2007, the BAH put in place cattle management requirements in the DNR-defined TB core area where cattle are at risk of exposure to TB from free-ranging infected white-tailed deer. The cattle producer requirements include:
    a. Annual whole-herd testing of all animals 12 months of age and older;
    b. BAH movement permit required and current TB test (within 60 days) to move any animal off the premises;
    c. Annual herd inventory submitted between May 1 and June 30 each year; and
    d. Wildlife risk assessment performed on each premises by USDA or BAH staff and all recommendations from the assessment summary implemented by the end of 2007. These recommendations included fencing stored feed, using covered mineral feeders in pastures, and using feeding practices in winter to minimize deer access to feed.

8. Statewide surveillance in both deer (n=4,000) and cattle herds (n=1,550) is completed. No bovine TB was identified in this surveillance.

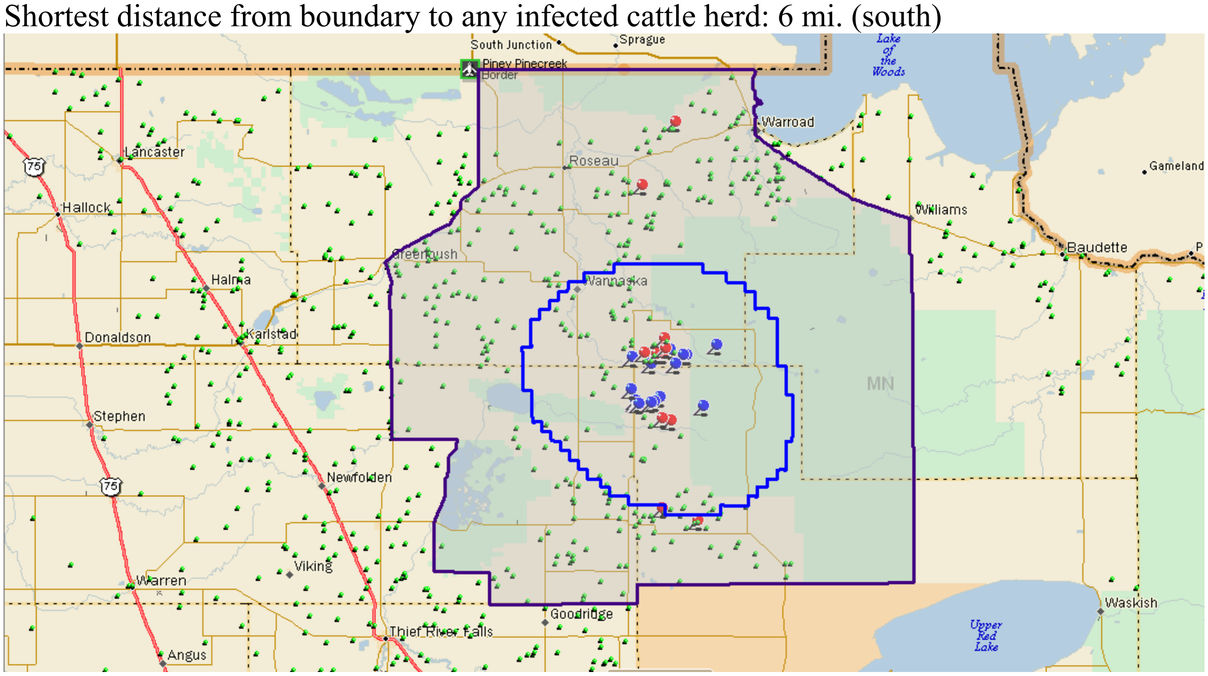
For additional background information, we can provide the TB annual report to USDA and the approved August 2006 TB Management Plan.

MA ZONE Defined



MA zone	
Management Area	
Infected deer	
Infected cattle herds	
Cattle premises	

Area: 6849 sq mi
Perimeter: 355 mi.
Cattle herds included: 300
Dairy Herds Included: 19
Shortest distance from boundary to any infected deer: 18 mi. (south)
Shortest distance from boundary to any infected cattle herd: 6 mi. (south)



MA zone

Zone criteria

The MA zone encompasses an area that includes a radius of 16.1 km (10.0 mi) around any infected cattle premises and approximately 40.2 km (25.0 mi) around any infected deer. A few adjustments have been made based on land use, e.g., State forest land where cattle are not present. Also the zone does not extend into the Red Lake Nation to the south since earlier investigations of this area indicated that cattle operations are not present here. The boundary of the zone is defined by existing roads to make it easier to identify which cattle premises are included in the zone.

General requirements

All bovine, bison, or cervid producers are required to provide farm location information to the Board. Official identification is required for all cattle leaving the zone.

TB surveillance in zone

All cattle herds in the zone would be tested annually.

Movement requirements

a. Requirements for movement of cattle movement **out of the zone**:
   - Feeders, steers, and spayed heifers: individual TB test within 60 days of movement.
   - Feeders, intact heifers: meet requirements for breeding animals, e.g., come from a herd that has had a WHT within 12 months and had individual tests within 60 days of movement.
   - Breeders must come from a herd that has had a WHT within 12 months and had individual tests within 60 days of movement.
   - Slaughter animals must be TB tested within 60 days of movement with the following exceptions:
     - Cattle moving directly to a Federal- or State-inspected slaughter facility where the official inspector is present to inspect the animals when they arrive; or
     - Cattle moving through a State-Federal market to a Federal- or State-inspected slaughter facility where the official inspector is present to inspect the animals when they arrive.

   All cattle moved out of the zone must be officially identified and be accompanied by an Intrastate Movement Certificate which includes a State-issued permit number or is signed by an authorized agent of the Board, and which shows the origin and destination of the animals with the following exception:
   - For animals moved out of the zone to another State, the movement certificate shall be replaced by a Certificate of Veterinary Inspection.

b. Requirements for movement of cattle **into and within the zone**:

All cattle moved into the zone or moved from one premises to another within the zone must be officially identified and be accompanied by an Intrastate Movement Certificate showing the origin and destination of the animals, including cattle brought into the zone for grazing.

Management Area (blue area in MA zone)

Management area criteria

This is an area within the MA zone where intensive management procedures will be implemented in order to minimize the potential for TB transmission within the area and to prevent spread out of the area. The area is determined by where bovine TB has been diagnosed in free-ranging deer and encompasses an area which includes a minimum of 11.3 km (7.0 mi) around all infected deer. The area is represented in the map above by the blue outline and currently includes 56 cattle herds with approximately 3,727 adult animals.

General requirements for cattle operations

All bovine, bison, or cervids producers are required to provide farm location information to the Board.
Official identification required for all cattle leaving a premises.
Deer-proof fencing around all stored feed.
Annual risk assessment with implementation of all requirements.
Annual WHT.
Annual inventory of all animals.
Must maintain all business records related to cattle movement for at least 5 years.
Herds in the AREA will not be eligible for TB accreditation.

TB surveillance in AREA

100 percent of herds tested annually.

Movement requirements

a. Requirements for movement of cattle **out of the AREA** (including cattle moved from the management area to a location in the MA zone which is outside of the management area):
   - Feeders, steers, and spayed heifers: individual TB test within 60 days of movement.
   - Feeders, intact heifers: meet requirements for breeding animals, e.g., come from a herd that has had a WHT within 12 months and had individual tests within 60 days of movement.
   - Breeders must come from a herd that has had a WHT within 12 months and had individual tests within 60 days of movement.
   - Slaughter animals must be TB tested within 60 days of movement with the following exceptions:
     - Cattle moving directly to a Federal- or State-inspected slaughter facility where the official inspector is present to inspect the animals when they arrive; or
     - Cattle moving through a State-Federal market to a Federal- or State-inspected slaughter facility where the official inspector is present to inspect the animals when they arrive.

All cattle moved out of the AREA must be officially identified and be accompanied by Intrastate Movement Certificate which includes a State-issued permit number or is signed by an authorized agent of the Board, and which shows the origin and destination of the animals with the following exception:

- When animals move out of the AREA to another State, the Intrastate Movement Certificate shall be replaced by a Certificate of Veterinary Inspection.

b. Movement of cattle **into and within the AREA**:
All cattle moved into the AREA or moved from one premises to another within the AREA must be officially identified and be accompanied by an Intrastate Movement Certificate showing the origin and destination of the animals, including cattle brought into the zone for grazing.

Accredited Free Zone

TB Surveillance in ZONE

The 25,700 herds in the AF zone would be sampled randomly to meet the UM&R requirement of 2 percent @ 95-percent confidence for sampling in zone, e.g., 149 herds. This testing would be divided over 2 years with 75 herds being tested each year.

Movement Requirements

Requirements for movement of cattle movement **out of the ZONE**: none

Movement **into and within the ZONE:** none

Appendix 6: Current Split-State Law in Minnesota as of May 5, 2008

A bill for an act

relating to agriculture; providing for control of bovine tuberculosis in certain areas; appropriating money; amending Minnesota Statutes 2006, section 97A.045, subdivision 11, by adding a subdivision; Minnesota Statutes 2007 Supplement, section 35.244; proposing coding for new law in Minnesota Statutes, chapter 35.

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF MINNESOTA:

Section 1. **[35.086] BOVINE TUBERCULOSIS MANAGEMENT ZONE; RESTRICTIONS.**

Subdivision 1. **Definitions.** (a) The definitions in this subdivision apply to this section.

(b) "Bovine tuberculosis management zone" means the area within the ten-mile radius around the five presumptive tuberculosis-positive deer sampled during the fall 2006 hunter-harvested surveillance effort.

(c) "Located within" means that the herd was kept in the area for at least a part of calendar year 2007.

Subd. 2. **Cattle herd buyout.** (a) The board shall offer a herd buyout payment to cattle owners with existing cattle that are located within the bovine tuberculosis management zone. The payment shall be $500 per bovine animal. By July 15, 2008, the cattle owner must accept or decline the offer for herd buyout payments under this subdivision. A cattle owner receiving payment under this subdivision must sign a contract with the board that provides:

(1) all cattle that are at least one year old and located within the bovine tuberculosis management zone will be slaughtered by January 31, 2009;

(2) all cattle that are less than one year old, are either slaughtered or moved out of the bovine tuberculosis management zone, as provided in paragraph (b), by January 31, 2009;

(3) the landowner and cattle owner will not have or allow any livestock to be located on land in the board's proposed modified accredited zone, unless authorized by the board; and

(4) a landowner or cattle owner who violates a condition under this subdivision must repay all payments received under this section and is subject to penalties for violations under this chapter.

(b) Cattle that are less than one year old, may be moved out of the bovine tuberculosis management zone to comply with paragraph (a), clause (2), only when:

(1) they are from a herd that received a whole herd tuberculosis test within the previous 12 months;

(2) they are not sexually intact; and

(3) they have had a tuberculosis test within 60 days of being moved out of the zone.

(c) After the effective date of this section, livestock shall not be moved into the bovine tuberculosis management zone unless authorized by the board.

(d) Before the board issues payment to a cattle owner under this subdivision, the board shall verify all cattle owned by that cattle owner and located within the bovine tuberculosis management zone have been slaughtered.

(e) A cattle owner who signs a contract under paragraph (a) or who depopulated an infected herd and signs a contract containing the provisions of paragraph (a), clauses (1) to (3), shall receive an annual payment of $75 for each bovine animal slaughtered. The board shall make the first annual payment by June 30, 2009, and make annual payments by June 30 each year thereafter until the area receives a bovine tuberculosis-free status and the owner is authorized by the board to have cattle located within the bovine tuberculosis management zone.

Subd. 3. **Cattle herds remaining in the zone.** The board shall conduct a risk assessment for cattle that remain located within the bovine tuberculosis management zone. If the board determines that cattle herds within the bovine tuberculosis management zone present a risk of interaction between cattle and deer or elk, the board shall require the owner of the cattle to keep all cattle in a manner that does not allow cattle and deer or elk interface. The board may also require that any person who stores forage crops within the bovine tuberculosis management zone, including but not limited to a person who participates in the herd buyout in subdivision 2, must keep stored forage crops in a manner that does not allow deer or elk access. The board shall offer cost-share assistance for fencing under subdivision 4 to a person who is required to:

(1) keep cattle in a manner that does not allow cattle and deer or elk interface; or

(2) keep stored forage crops in a manner that does not allow deer or elk access.

Subd. 4. **Cost-share assistance for fencing.** (a) The board shall provide cost-share assistance to persons required to fence stored forage crops or fence cattle in areas where the board determines that there is an unacceptable risk of transmitting bovine tuberculosis to deer or elk. The cost-share payments shall be 90 percent of the cost of an approved fence up to a maximum cost-share payment of $75,000. The payments under this subdivision shall be on a reimbursement basis and paid by the board after the board determines that the fence is built to the specifications required by the board.

(b) The board shall establish specifications for fences that qualify for cost-share assistance under this subdivision and provide cattle owners or those who store forage crops with a list of approved fencing contractors. The fencing must be constructed and maintained by an approved fencing contractor, the landowner, or the tenant.

(c) The board shall periodically inspect fences for which cost-share assistance has been received under this subdivision. If the board determines that a fence for which cost-share assistance has been received is not being maintained or used properly, the board may:

(1) order that the fence be repaired or used properly; or

(2) require repayment of any cost-share assistance received by the person and, if the fence was intended to keep cattle in a manner that does not allow cattle and deer or elk interface, the board may place the herd under quarantine.

Sec. 2. Minnesota Statutes 2007 Supplement, section 35.244, is amended to read:

35.244 ~~RULES FOR~~ CONTROL OF BOVINE TUBERCULOSIS.

Subdivision 1. **Designation of zones.** The board has the authority to control tuberculosis and the movement of cattle, bison, goats, and farmed cervidae within and between tuberculosis zones in the state. Zones within the state may be designated as accreditation preparatory, modified accredited, modified accredited advanced, or accredited free as those terms are defined in Code of Federal Regulations, title 9, part 77. The board may designate bovine tuberculosis control zones that contain not more than 325 herds.

Subd. 2. **Control within modified accredited zone.** In a modified accredited zone, the board has the authority to:

(1) require owners of cattle, bison, goats, or farmed cervidae to report personal contact information and location of livestock to the board;

(2) require a permit or movement certificates for all cattle, bison, goats, and farmed cervidae moving between premises within the zone or leaving or entering the zone;

(3) require official identification of all cattle, bison, goats, and farmed cervidae within the zone or leaving or entering the zone;

(4) require a whole-herd tuberculosis test on each herd of cattle, bison, goats, or farmed cervidae when any of the animals in the herd is kept on a premises within the zone;

(5) require a negative tuberculosis test within 60 days prior to movement for any individual cattle, bison, goat, or farmed cervidae moved from a premises in the zone to another location in Minnesota, with the exception of cattle moving under permit directly to a slaughter facility under state or federal inspection;

(6) require a whole-herd tuberculosis test within 12 months prior to moving cattle, bison, goats, or farmed cervidae from premises in the zone to another location in Minnesota;

(7) require annual herd inventories on all cattle, bison, goat, or farmed cervidae herds; and

(8) require that a risk assessment be performed to evaluate the interaction of free-ranging deer and elk with cattle, bison, goat, and farmed cervidae herds and require the owner to implement the recommendations of the risk assessment.

Subd. 3. **Authority to adopt rules.** The board may adopt rules to provide for the control of tuberculosis in cattle. The rules may include provisions for quarantine, tests, and such other measures as the board deems appropriate. Federal regulations, as provided by Code of Federal Regulations, title 9, part 77, and the Bovine Tuberculosis Eradication Uniform Methods and Rules, are incorporated as part of the rules in this state.

Sec. 3. Minnesota Statutes 2006, section 97A.045, subdivision 11, is amended to read:

Subd. 11. **Power to prevent or control wildlife disease.** (a) If the commissioner determines that action is necessary to prevent or control a wildlife disease, the commissioner may prevent or control wildlife disease in a species of wild animal in addition to the protection provided by the game and fish laws by further limiting, closing, expanding, or opening seasons or areas of the state; by reducing or increasing limits in areas of the state; by establishing disease management zones; by authorizing free licenses; by allowing shooting from motor vehicles by persons designated by the commissioner; by issuing replacement licenses for sick animals; by requiring sample collection from hunter-harvested animals; by limiting wild animal possession, transportation, and disposition; and by restricting wildlife feeding.

(b) The commissioner shall restrict wildlife feeding within ~~a 15-mile radius of a cattle herd that is infected with bovine tuberculosis~~ the modified accredited bovine tuberculosis zone proposed by the Board of Animal Health. In addition to any other penalties provided by law, a person who violates wildlife feeding restrictions required under this paragraph may not obtain a hunting license to take a wild animal for two years after the date of conviction.

(c) The commissioner may prevent or control wildlife disease in a species of wild animal in the state by emergency rule adopted under section 84.027, subdivision 13.

Sec. 4. Minnesota Statutes 2006, section 97A.045, is amended by adding a subdivision to read:

Subd. 13. **Collection of deer and elk in a bovine tuberculosis zone.** The commissioner of natural resources, in consultation with the Board of Animal Health, shall remove, upon request, deceased deer and elk within the modified accredited bovine tuberculosis zone proposed by the Board of Animal Health. The commissioner shall make a good faith effort to inform the state's residents of this requirement and how a person may make a deer or elk removal request. The commissioner is not required to continue these collections once the split state zone is upgraded by the United States Department of Agriculture to a bovine tuberculosis status of modified accredited advanced or better.

Sec. 5. **BOVINE TUBERCULOSIS CONTROL ASSESSMENT; TEMPORARY ASSESSMENT; APPROPRIATION.**

(a) From January 1, 2009, to December 31, 2009, a person who purchases a beef cow, heifer, or steer in this state shall collect a bovine tuberculosis control assessment of $1 per head from the seller and shall submit all assessments collected to the commissioner of agriculture at least once every 30 days. For the purposes of this section, "a person who purchases a beef cow, heifer, or steer in this state" includes the first purchaser, as defined in Minnesota Statutes, section 17.53, subdivision 8, paragraph (a), and any subsequent purchaser of the living animal.

(b) Money collected under this section shall be deposited in an account in the special revenue fund and is appropriated to the Board of Animal Health for bovine tuberculosis control activities.

(c) Notwithstanding paragraph (a), a person may not collect a bovine tuberculosis control assessment from a person whose cattle operation is located within a modified accredited zone established under Minnesota Statutes, section 35.244, unless the cattle owner voluntarily pays the assessment. The commissioner of agriculture shall publish and make available a list of cattle producers exempt under this paragraph.

Sec. 6. **APPROPRIATION.**

(a) $472,000 in fiscal year 2008 and $2,172,000 in fiscal year 2009 are appropriated from the general fund to the Board of Animal Health for monitoring, testing, eradication, education, outreach, and other activities the board is required to undertake to comply with federal regulations concerning cattle, bison, goats, and farmed cervidae under a United States Department of Agriculture modified accredited status. The appropriation for fiscal year 2009 is added to the base.

(b) $80,000 is appropriated in fiscal year 2009 from the general fund to the Board of Regents of the University of Minnesota for a study at the North Central Research Center at Grand Rapids of the best management practices for control of bovine tuberculosis in pasture. This appropriation is added to the base.

(c) $3,350,000 is appropriated in fiscal year 2008 from the general fund to the Board of Animal Health for cattle herd buyout payments, annual payments, and fencing cost-share assistance under Minnesota Statutes, section 35.086. This is a onetime appropriation and is available until spent.

(d) $150,000 is appropriated in fiscal year 2008 from the general fund to the Board of Animal Health for a grant to the North Central Research Center at Grand Rapids for a study of the best management practices for control of bovine tuberculosis in pasture. This is a onetime appropriation and is available until spent.

(e) If an appropriation for the same purpose is enacted in 2008 H.F. No. 1812, the comparable appropriation in that act is void.

Sec. 7. **EFFECTIVE DATE.**

Sections 1 to 6 are effective the day following final enactment.