DEPARTMENT OF NATURAL RESOURCES

HEALTH ASSESSMENT FOR FREE-RANGING ELK IN MINNESOTA, FROM 2004-2023

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SUMMARY OF FINDINGS

The goal of this project was to assess the health of free-ranging elk (*Cervus elaphus)* in Minnesota, most of which are located in northwest Minnesota (NW MN) by screening animals for a variety of diseases and parasites. Results indicate which diseases MN elk were exposed to, even if they never became clinically ill. From the elk (*n*=359) included in this study, our results indicate elk are exposed to anaplasmosis (14.8%), borreliosis (67.8%), bovine herpes virus (2.3%), bovine viral diarrhea virus 1 and 2 (5%), eastern equine encephalitis (10.3%), *Leptospira* sp. (6.5%), malignant catarrhal fever (23.4%), parainfluenza virus 3 (31.9%), and West Nile virus (57.5%). A variety of fecal parasites were also identified (*Coccidia, Strongyle-type ova,* and *Moniezia*) in 29.8% of elk examined. Lung and liver tissue were cultured for bacterial infection; *Streptococcus sp.* was isolated from the lung of one individual and no isolations were found in liver samples. All elk were negative for blue tongue virus, bovine tuberculosis, brucellosis, chronic wasting disease, epizootic hemorrhagic disease, *Mycobacterium paratuberculosis,* and western equine encephalitis.

INTRODUCTION

Elk in Minnesota

Elk (*Cervus elaphus*) are native to Minnesota and were originally distributed across most of the state. They were formally protected from hunting in 1893 and by the early 1900s, over-hunting and prairie conversion to agriculture led to a functional extirpation (Hazard 1982, Swanson 1940).

Reintroduction efforts were initiated in 1914 and 1915 using elk from Yellowstone National Park and Jackson, Wyoming that were translocated to Itasca State Park in north central Minnesota. The herd expanded and in 1935, 27 elk were moved from Itasca State Park to the Red Lake Game Preserve in northwest Minnesota. By the 1940s, the northwest elk population was estimated at nearly 100 animals (MNDNR 2015). Currently, this population (herein referred to as the “Grygla herd”) occupies a 45 mi_2 area north of Grygla, Minnesota (Figure 1). Existence of these animals has been controversial and in 1987, the Minnesota Legislature mandated the pre-calving population range between 20–30 animals. Consequently, the Minnesota Department of Natural Resources (MNDNR) instituted elk hunts in 1987, 1996, 1997, and 1998; however, few animals were taken each year (MNDNR 2015). From 2004-2012, state hunts were held annually to keep elk numbers between 30 and 38 animals**.** State hunting has been suspended since 2013 because the population surveys indicated numbers were below the goal range of 30-38 animals. The 2020, 2022, and 2023 aerial surveys counted 24, 29, and 29 elk, respectively (MNDNR 2023).

Two more herds of elk occur in Kittson and Roseau Counties (Figure 1) and are termed the Kittson Central and Caribou-Vita herds. These animals were first observed along the Manitoba

border in the early 1980s. The Caribou-Vita herd is known to occupy either side of the international border at any time of year. Little is also known regarding the extent of animal interchange between the Caribou-Vita subgroup and the other two subgroups (MNDNR 2015). Due to crop depredation issues, the first hunting season was opened in 2008 and is held annually to meet population goals that were established through a public process (MNDNR 2015). The most recent elk survey conducted in 2023 counted 75 animals in the Kittson Central herd and 227 for the Caribou-Vita herd. The current Elk Management Plan set a pre-calving population goal for Kittson Central herd at 50-60 elk, while the population goal for the Caribou-Vita herd (shared internationally between Manitoba Conservation and MNDNR) is 150-200 elk.

Elk population goals reflect social carrying capacity related to landowner tolerance, and to a lesser extent, habitat availability. In fact, the Minnesota elk population is intentionally held at low levels due to social conflicts and local landowner priorities. State law, as of April 2024, only allows an elk population increase in northwestern Minnesota when agricultural damage payments have not increased for at least two years.

Research background

Infectious diseases can reduce reproductive rates and increase mortality and are thus known to regulate wildlife populations (Delahay et al., 2009). For example, meningeal worm (*Parelaphostrongylus tenuis*) has been implicated in both failures to reestablish eastern elk populations and elk population declines in sympatric white-tailed deer range (Raskevitz et al., 1991; McIntosh et al., 2007). Other research has shown that meningeal worm has a minimal long-term impact on elk population growth in Michigan (Bender et al., 2005) or Kentucky (Bolling, 2009). Conversely, research on northwestern Minnesota moose indicated parasites and disease as reasons that population collapsed (Murray et al., 2006).

The objective of our study was to conduct a health assessment of Minnesota elk that included: 1) serological survey of pathogens that are known to cause mortality in other mammalian species or are important from a human health perspective; 2) analysis of fecal material for parasites; and 3) examination of tissues to ascertain presence of bacterial infection. Results of this testing could be used to make inferences regarding the potential limiting factors related to elk herd expansion, explanation of disease transfer risk (both zoonotic and wild-domestic), and explanation of potential disease risks to this population.

Further, the discovery of bovine tuberculosis (TB) in cattle and free-ranging deer from 2004-2009 has brought increased scrutiny as to the health status of the northwest Minnesota elk, particularly the Grygla herd. While overlap in range between elk and known TB-infected deer or cattle farms is known to occur, there has been no evidence of TB-infection in MN's elk herd. TB-infected cattle and deer in MN shared the same strain, which is considered of Mexican or southwest US origin, and was not related to the strain of bovine TB found in elk in Manitoba's Riding Mountain National Park. Although Minnesota is now declared 'bovine TB' free, interest remains regarding the role elk may play in future disease maintenance and/or transmission.

METHODS

For this report, elk sampled were grouped as either *harvested* animals (including hunter-harvested, removed under shooting permit, and illegally poached) or *other* (including vehicle kills, sick, and found dead elk). All elk within the harvested category were assumed to be representative of healthy individuals within the population.

For all years of the study, hunters presented their harvested animals to MNDNR staff in order to collect samples of hair, muscle, cranial lymph nodes, obex and an incisor for aging from hunter-harvested elk. For a portion of this study (2004-2015), hunters were also asked to collect samples of lung, liver, feces, blood, hair, and ticks. MNDNR provided a project overview,

instructions of sample collection, and sampling kits at the mandatory elk hunter orientation sessions. Elk shot through depredation permits or other methods were sampled by trained MNDNR staff. For sick animals, displaying clinical signs of illness, every effort was made to obtain intact carcasses for full necropsy at the University of Minnesota Veterinary Diagnostics Laboratory (VDL), St. Paul, MN.

All equipment needed for hunter-harvested sampling was included in the sampling kit: soft-sided cooler; 1-60cc syringe for blood collection; 6-15cc serum tubes for blood storage; 3 whirlpaks for a sample of liver, lung, and feces; 2 specimen jars with formalin for liver and lung samples; 2 coin envelopes for hair and tooth; datasheet; protocol; Sharpie marker; 1 pair of large vinyl gloves; and 1 ice pack. Successful hunters dropped off their sampling kits when they registered their animal; hunters also provided information on the location of their kill.

Hunters collected blood from the chest cavity as soon after death as possible, using a 60cc syringe. The blood was placed in serum tubes and kept cool until delivered to official MNDNR registration station. Liver and lung samples were collected and split, with half placed in a formalin jar, while the other half was frozen in whirlpak bags. If the hunter found anything unusual, such as a large abscess or tumor, those samples were also collected and split between the preservation methods (formalin fixation and freezing). Complete sets of samples were not collected from all elk included in this project, as field conditions and sample quality varied; however, there were very few errors in tissue identification or insufficient sample quantities in those submitted. Blood was centrifuged at the registration stations and serum was extracted and frozen. Cranial lymph nodes and obex were removed by trained MNDNR staff at the registration stations to allow for chronic wasting and bovine tuberculosis testing. Where appropriate, MNDNR made arrangements with taxidermists to collect samples from trophy animals. All samples were submitted to the VDL, where the majority of the testing occurred; some tests were outsourced to the National Veterinary Services Laboratories (NVSL) in Ames, IA. Teeth were sent to Matson's Laboratory (Milltown, MT) for aging by cementum annuli.

RESULTS

A total of 359 elk (178 females, 181 males) were included in this health assessment project (Figure 2). Harvested elk accounted for 293 (82%) of the animals (265 hunter-harvested, 24 shooting permits/removals, and 4 poached). In addition, 66 other animals were sampled including 20 live captures, 2 capture-mortalities, 10 creating issues with captive herds, 13 vehicle killed, 6 found dead, 8 clinically ill (observed with neurological symptoms) that were euthanized by gunshot, and 7 other opportunistic elk. Exact age was determined for 313 elk by examining dentition for calf and yearling elk, or cementum annuli for adults ($\bar{x}$ = 4.2 years; *SE*= 3.34years; range 0.5 to 20 years old (Figure 3).

Serologic results from harvested elk indicate exposure to anaplasmosis, borreliosis, bovine herpes virus 1, bovine viral diarrhea virus 1 and 2, Eastern equine encephalitis, *Leptospira* spp, malignant catarrhal fever, parainfluenza virus 3, and West Nile virus (Table 1).

Our testing indicated that elk in NW MN were not exposed to blue tongue virus, bovine tuberculosis, brucellosis, chronic wasting disease, epizootic hemorrhagic disease, mycobacterium paratuberculosis, Neospora, or Western equine encephalitis (Table 1).

Fecal samples

Fecal samples for 123 elk were evaluated for parasites by fecal floatation and 71.5% (n=88) were negative for parasites. Of the positive samples, yeast (28.5%), *Fascioloides magna* (*F. magna*) (20%), Strongyle-type ova (22.9%), *Moniezia* spp (5.7%), Mite ova (5.7%), Coccidia oocyst (2.8%), and combinations of such (14.2%) were present. Negative results do not

necessarily mean the animal was parasite-free, only that it was not actively shedding at the time the feces were collected.

Evidence of P. tenuis

A total of 48 (4 reported sick, 1 vehicle kill, 43 hunter-harvested) whole brains were submitted from elk in this study and assessed histologically. Nearly two-thirds (n=33 or 68.7%) of the brains submitted had no significant microscopic lesions noted. Of the brains submitted with lesions noted, 7 were consistent with evidence of *P. tenuis* infection in the form of migration tracts. The remaining 7 brains with lesions were consistent with lymphocytic/lymphoplasmacytic encephalitis of unknown cause.

Mosquito-borne diseases

Positive results were reported for 21 (10.3%) and 112 (57.7%) elk tested for Eastern equine encephalitis (EEE) and West Nile Virus (WNV), respectively (Table 1). Both of these arboviruses are spread by mosquitoes, with EEE typically posing a greater mortality treat to most species. Clinical signs of EEE in horses and sheep involve neurologic signs and often death (Bauer et al. 2005, Rutledge 2008). It is also a zoonotic disease and human infections are reported to the Center for Disease Control. Schmitt et al. (2007) reported clinical infection of EEE in free-ranging white-tailed deer (*Odocoileus virginianus*) in Michigan, suggesting this disease can cause mortality in wild cervids and maybe often be overlooked if biologists are only seeking to rule-out chronic wasting disease (CWD).

Little is known about the effects of WNV in elk. Palmer at al. (2004) reported WNV infection in 2 reindeer (*Rangifer tarandus)*, which was the first confirmed cases of this disease in cervids. A wild white-tailed deer in Georgia was reported to die from a WNV infection (Miller et al., 2005). As with EEE, clinical signs of WNV include ataxia, tremors, head tilt, and depression; which are commonly reported neurological signs in wild cervids with numerous causes (e.g., brain abscess, CWD, blunt trauma, etc.); thus, true WNV infection may be under-reported.

Lyme disease

Positive results were reported for 139 (67.8%) and 4 (3.8%) elk tested for *borrelia burgdorferi* (Lyme disease; Table 1). Borreliosis is a tick-borne (*Ixodes sp*.) bacterial disease that is maintained through sylvatic cycles involving a variety of species, including mammals (primarily wild rodents as the reservoir hosts) and birds. Clinical disease typically includes arthritis and neurologic or cardia dysfunction. While evidence of natural infection exists in wild cervids through serosurveys, there has been no documentation of clinical disease in elk.

Anaplasmosis

Anaplasmosis (*Anaplasma marginale*) infection in cattle results in bacteria destroying red blood cells resulting in loss of condition, reduced mild production, inappetence, and possible abortions (Kocan et al. 2003). Experimental studies have shown that elk can harbor asymptomatic infections with *A. marginale* and *A. ovis,* the causes of anaplasmosis in cattle and sheep, respectively. However, efforts to recover *Anaplasma* spp. from free-ranging elk populations have been unsuccessful, suggesting that even though these species are susceptible, they are probably not responsible for maintaining infections or acting as a source of infection for cattle (Corn et al., 2001). Between 2004-2014, only 4 of 104 MN elk were positive (4%). However, in 2016 we learned that the commercial test utilized for livestock was not validated to perform accurately for wild animals, including elk. To determine if the *Anaplasma* spp carried by elk in Minnesota is associated with a livestock strain, a University of Minnesota Entomologist, Dr. Uli Mundeloh, used molecular screening to determine the strain in Minnesota elk is a full match to a strain found in British Columbia mule deer, and not *A. marginale* or *A. ovis.* Further work

completed by Dr. Pauline Kamath (Associate Professor of Animal Diseases, University of Maine) demonstrated the presence of 2 *Anaplasma* spp strains in MN elk (43/83 = 52% seroprevalence, 2016-2020), but they are not closely related to livestock strains of *Anaplasma* spp, such as *A. marginale* and *A. centrale*.

Malignant Catarrhal Fever

A total of 46 (23.4%) elk were positive for peroxidase-linked assay (PLA) testing for malignant catarrhal fever (MCF) in this study (Table 1). Virus neutralization (VN) testing is performed on all PLA-positive samples; however, all elk were negative on VN. The PLA test is more sensitive than the virus isolation, meaning it is much better at identifying true positives. Whereas, VN is more specific, which means it is better at identifying true negatives. There are a couple of concerns with this testing. First, the PLA reacts with multiple gammaherpes viruses (including strains from wildebeest, sheep and deer). A PLA-positive test does not indicate which strain has been found, only indicated that one of the various strains was detected. The higher the positive value with the PLA test, the stronger the positive in the sample. Second, the VN test only screens for the wildebeest strain (which is exotic to the U.S. and a reportable foreign animal disease) and would be negative if other strains are present. This means a sample that was positive on PLA and negative on VN was likely exposed to a gammaherpes virus, but not the wildebeest strain. We do not know for certain what stain of MCF elk are being exposed to in NW MN.

Gammaherpes viruses have been documented to cause serious illness and death in elk and other ruminants. The clinical symptoms can mimic *Parelaphostrongylus tenuis* infection as the animals often exhibit neurological deficits, blindness, high fever, and salivation. While infection with MCF frequently results in death, carrier status can occur and is identified with serology. Li et al. (1996) found small numbers of United States free-ranging elk were seropositive; these animals were once exposed to MCF viruses but whether they had recovered from a non-lethal disease is unknown. A serosurvey to MCF in Alaskan wildlife reported high antibody prevalences for several wildlife species including 96% in muskox (*Ovibos moschatus*), 95% in Dall sheep (*Ovis dalli*), and 27% in elk; impact on survival is unknown (Zarnke et al. 2002).

Cattle-borne Diseases: Bovine Viral Diarrhea Virus (BVD) 1 and 2, Bovine Herpes Virus 1 (BHV), and Parainfluenza Virus 3 (PI)

Positive results were reported for 11 (5%) and 5 (2.3%) of elk tested for BVD and BHV, respectively (Table 1). BVD is considered a major disease of cattle and is thought to be the most common infectious cause of reproductive failure in beef herds in the western U.S. BVD also causes enteritis, mucosal disease, infections, and respiratory disorders in cattle, though experimentally inoculated non-pregnant elk showed no clinical signs and remained healthy for >50 days post inoculation (Barber-Meyer et al, 2007). Tessaro et al. (1999) demonstrated that while experimentally inoculated elk do not show sign of the disease, they can shed and transmit BVD once exposed. Natural exposure of BVD to wild ungulates suggests a spillover from cattle or maintenance within wildlife populations (Duncan et al. 2008).

Bovine herpes virus type 1 is a disease that can lead to respiratory tract disorders, conjunctivitis, genital disorders and immune suppression. It is believed to infect all ruminant species and has been isolated from a large number of wild species. It is most commonly isolated in feedlot cattle. As with BVD, exposure of elk in NW MN to BHV, both cattle-borne diseases, demonstrates contact between these species (direct or indirect) is sufficient to promote exchange of pathogens.

A total of 68 elk (31.9%) were positive for exposure to parainfluenza virus 3 (Table 1). Domestic ruminants are considered the main source of infection for free-ranging ruminants. PI causes

mild respiratory disorders in domestic cattle and sheep that serve as initiators for secondary infections of *Pasteurella* spp., which can result in bacterial pneumonia, but clinical symptoms in wild elk remains unknown (Barber-Meyer et al, 2007).

Leptospirosis

Leptospirosis is a bacterial disease that can infect a wide variety of mammals, both domestic and wild. In ungulates, it causes abortion (Fraser and Mayes, 1986). Exposure usually occurs through direct contact with urine from carrier animals or indirectly by contact with a urine-contaminated environment (Bender and Hall, 1996). Much of the landscape of NW MN contains environments where moist alkaline soils are present to house the bacteria, and it may survive for several weeks (Thorne 1982).

A total of 219 elk were screened for 6 species of *Leptospira,* using a microscopic agglutination test (MAT); 31 elk 16.5%) were exposed to at least one strain, 3 elk was co-infected with multiple strains of *Letospira* (Table 1). Free-ranging elk in Washington had high seroprevalence to *Leptospira interrogans* and high local productivity, suggesting clinical affects may be more dramatic in cattle (Bender and Hall, 1996).

Liver Grading

Fixed and fresh whole livers submitted from elk (N=191) were evaluated for evidence of liver fluke (*Fascioloides magna*) infestations by liver grading or histopathology. 110 (59.1%) livers were submitted for histopathology only and 82 (42.4%) were submitted for liver grading. Results of liver grading indicated that 19.5% were not affected, 52.4% were mildly affected, 20.7% were moderately affected, and 7.3% were markedly affected.

Liver fluke-induced hepatitis can be a major health concern for elk, and it was also the leading cause of health impacts for moose in northwest MN (Murray et al. 2006). Mild infestations, in the absence of other comorbidities, can be tolerated; however moderate to marked liver fluke loads can make animals susceptible to bacterial infections and adversely affect elk survival.

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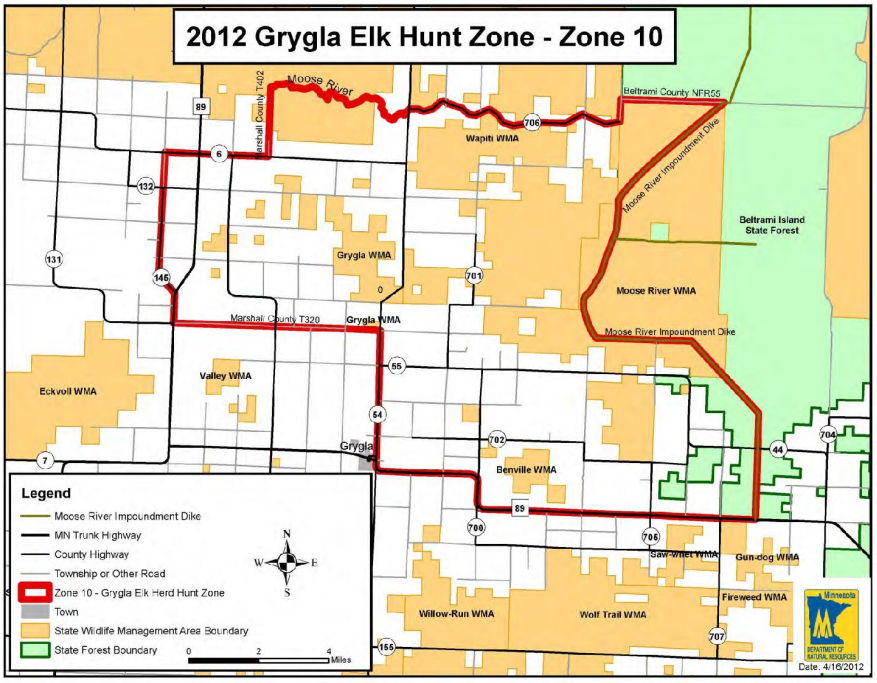
Table 1. Serological and tissue test results from elk in Minnesota, 2004-2023.

Disease	*n*	Apparent prevalence (number of positives)
Anaplasmosis*	128	14.8% (n=19)
Blue tongue virus	118	0%
Borreliosis	205	67.8% (n=139)
Bovine Herpes Virus	218	2.3% (n=5)
Bovine viral diarrhea (Type 1&2)	220	5% (n=11)
Bovine tuberculosis	239	0%
Brucellosis	118	0%
Chronic wasting disease	292	0%
Eastern equine encephalitis	204	10.3% (n=21)
Epizootic hemorrhagic disease	120	0%
Leptospira Bratislava	200	6.5% (n=13)
Leptospira Canicola	200	0%
Leptospira Grippothyphosa	200	4% (n=8)
Leptospira Hardjo	200	1.5% (n=3)
Leptospira Interrogan Serovar Icterohaemorrhagicae	219	4.5% (n=10)
Leptospira Pomona	200	1.5% (n=3)
Mycobacterium paratuberculosis	129	0%
Malignant catarrhal fever	196	23.4% (n=46)
Neospora	111	0%
Parainfluenza virus 3	213	31.9% (n=68)
West Nile virus	194	57.7% (n=112)
Western equine encephalitis	16	0%

Figure 1. Grygla(*a*) and Kittson Central and Caribou Vita (*b*) hunting zones in northwest MN.

a)



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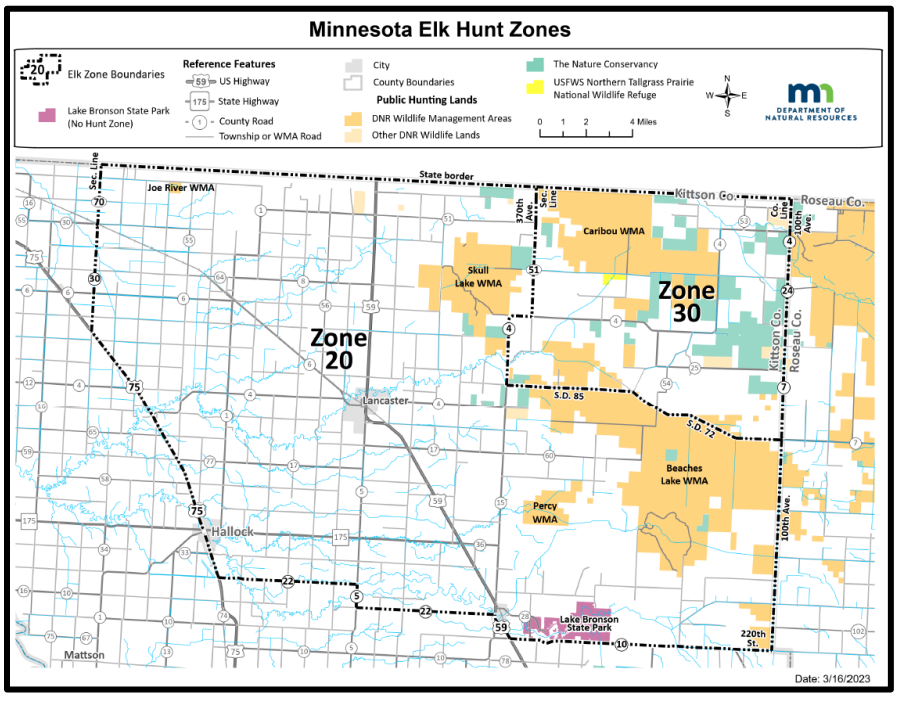

Figure 2. Locations of elk (n=359) sampled for health status in northwest Minnesota, 2004-2023.

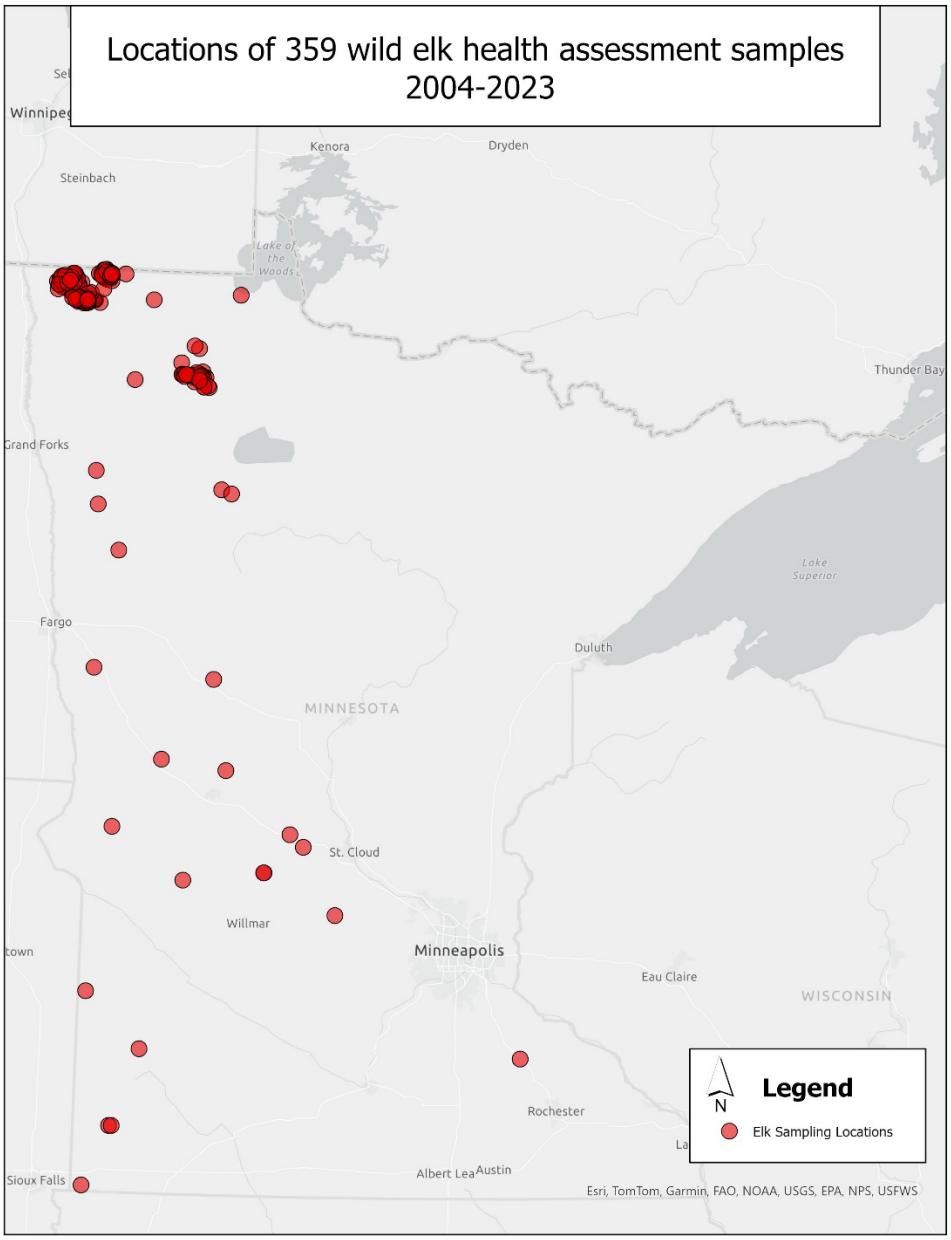

Figure 3. Age distribution of elk (n=313) sampled in northwest MN from 2004-2023, with known ages in years (via detention for calves and yearlings, or cementum annuli for adults). Ratios for female:male by year are displayed in color.