Chronic Wasting Disease Surveillance in North Carolina

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Abstract: Although chronic wasting disease (CWD) has not been documented in any samples (N = 2,447) collected in North Carolina, the potential biological, economical, and sociological implications associated with this disease are significant. Discovery of CWD in Wisconsin prompted the North Carolina Wildlife Resources Commission (NCWRC) to implement a preventative disease management strategy in May 2002. Revisions to administrative rules pertaining to captive cervids were implemented, including testing, tagging, and inspection requirements. A short-term buyout program was established to compensate individuals voluntarily relinquishing their cervid herd and captivity license to NCWRC. Minimizing occurrence of illegally-held cervids was also a goal. Monitoring and surveillance of CWD were expanded for free-ranging white-tailed deer (*Odocoileus virginianus*), including a statewide, systematic sampling of hunter- and road-killed deer and free-ranging deer located around captive cervid facilities. Information was disseminated to increase public awareness of CWD and disease management actions implemented by NCWRC. All management actions implemented by NCWRC have been designed to prevent introduction of CWD into North Carolina or to increase likelihood of detection should it exist.

Key words: captive cervids, chronic wasting disease, white-tailed deer, disease surveillance, North Carolina, *Odocoileus virginianus*, wildlife disease

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Control of chronic wasting disease (CWD) is problematic for wildlife management agencies because of its infectious nature and long incubation period, subtle clinical signs in infected animals, absence of a reliable live-test, possible environmental contamination, and an incomplete understanding of transmission mechanisms (Williams and Miller 2002). Spread of CWD is also unpredictable and inadequately regulated in many locations primarily due to transportation of animals in the commercial cervid industry (Williams and Miller 2002). Determining if a captive cervid herd is "CWD-free" is difficult because the incubation period of the disease is variable. Thus, effectively managing captive cervid herds has become a major issue for wildlife management agencies. Although there are relatively few captive cervid herds in North Carolina, the most likely vectors for introduction of CWD into North

Carolina, is through transportation of captive cervids or importation of infected carcasses (Miller et al. 2004).

White-tailed deer (*Odocoileus virginianus*) is one of the most abundant and most hunted species in North Carolina. Deer hunters contributed US$1.06 billion to the state's economy in 2001 (IAFWA 2002). Wildlife watchers, researchers, and other members of the general public also have an interest in white-tailed deer. Therefore, white-tailed deer management, including disease surveillance, is of paramount importance. Our objectives were to evaluate presence of CWD in captive cervids and free-ranging white-tailed deer and to establish a program to minimize the potential of introduction or spread of CWD in the state.

Methods

In 2002, after CWD was first documented east of the Mississippi River, the North Carolina Wildlife Resources Commission (NCWRC) amended wildlife captivity rules and created a Captive Cervid Program to monitor captive cervid herds for CWD. Active surveillance efforts were also initiated to detect the presence of disease in free-ranging white-tailed deer.

Captive Cervid Program

Facility Inspections.—Inspections of each captive cervid facility in North Carolina occur during winter (October–December) and summer (May–June). Winter inspections are conducted by a NCWRC enforcement officer, NCWRC biologist, and licensed veterinarian from the North Carolina Department of Agriculture and Consumer Services (NCDA&CS). Primary objectives of winter inspections are to obtain an updated inventory for each facility, monitor compliance with captivity rules, monitor herd health, and review records on CWD testing and fence inspection maintained by the licensee. Summer inspections are conducted by NCWRC enforcement officers who monitor compliance with captivity rules and verify that deficiencies noted at previous inspections have been corrected.

CWD Testing Protocol.—The NCDA&CS began voluntary testing of captive cervids for CWD in 2001. Licensees were not required by rule to test cervids that died within their captive cervid facility for CWD until the NCWRC passed emergency rules in May 2002. These rules required that all captive cervids ≥6 months of age, regardless of cause of death, and any cervid exhibiting clinical signs of CWD, be submitted for CWD evaluation. The NCDA&CS sends all tissue samples to the National Veterinary Services Laboratory in Ames, Iowa, for CWD evaluation. All other captive cervids ≥6 months of age confiscated, voluntarily relinquished, or obtained through the buyout program were also tested for CWD.

Buyout Program.—In May 2002, the NCWRC established a voluntary buyout program to provide an opportunity for licensees to relinquish their Wildlife Captivity License and their entire cervid herd for CWD evaluation. Reimbursement rates were based on the current market values of individual captive cervids in May 2002:

$1,000 for each adult elk, $500 for calf elk, $600 for each adult white-tailed deer, $300 for each deer fawn, $500 for each adult of other species, $250 for each fawn of other species.

CWD Surveillance of Free-ranging White-tailed Deer

Surveillance periods occur from 1 July of each year indicated through 30 June of the following year. Animals collected through systematic sampling were killed primarily by hunters and vehicles.

Historical Surveillance (1999–2001).—CWD samples collected and tested during 1999–2001 were not collected as part of a systematic CWD sampling effort. Most samples were collected from animals displaying clinical symptoms characteristic of CWD and animals collected for herd health evaluations. Herd health evaluations were conducted for number of condition-related parameters (e.g., abomasal parasite counts, internal/external parasites, serologic tests) from free-ranging deer.

Priority Area Surveillance (2002).—Seventeen captive cervid facilities were identified as having the highest risk for transporting CWD-infected deer into the state because they acquired cervids from out of state within the past five years. Protocols called for the collection of samples from 10 free-ranging white-tailed deer within a 5-mile (8.0 km) radius of each priority area.

Statewide Surveillance (2003).—With the assumption CWD would be present at a prevalence rate of 0.5% in the statewide population, and that the disease would be distributed evenly throughout the state, we estimated that ≥919 samples would provide a 99% level of confidence that the disease would be detected (Cannon and Roe 1982). The sampling design ensured that sample locations were well distributed across the state by utilizing the North Carolina Forest Service quad-block-square mapping system. Under this mapping system, one square consisted of 2.6 km^2, one block consisted of 25 squares, and one quad consisted of 144 blocks. Protocols called for 1,000 quota samples to be collected, where a quota sample was defined as a sample that falls outside of a 3-square buffer from any previously-collected quota sample. Samples that fell within three full squares of a previously-collected quota sample were considered nonquota samples and did not count toward the 1,000 sample objective.

To determine how many samples should be collected from each county, and to vary regional sampling intensity based on white-tailed deer population densities, the 1,000-sample objective was apportioned in two steps to the county level. The sample objective was first apportioned to the white-tailed deer management zone level based on relative population density within each of the states 15 management zones. A sample quota was assigned to each county within each management zone based on relative amount of deer habitat in each county. Deer habitat was defined as amount of harvested cropland and forested land in each county.

Priority Area Surveillance (2004).—Surveillance focused on collection of samples around captive cervid facilities considered among the highest risk for exposing free-ranging white-tailed deer to CWD. High risk facilities included those that were known to have imported captive cervids from out of state or those that were known

to have acquired deer from in-state sources that had acquired deer from out of state. Two such areas were established within each of the NCWRC's nine districts. Six of these 18 priority areas were also priority areas during the 2002 surveillance year.

Our sampling protocol ensured sample locations were well distributed within each priority area. Each priority area consisted of three concentric circles with radii of 1.6, 4.8, and 8.0 km centered around each facility. A point value was assigned to samples collected within each circle. Samples collected ≤1.6 km of each priority area were assigned a point value of three, samples collected from 1.6–4.8 km from each priority area were assigned a point value of two, and samples collected from 4.8–8.0 km from each priority area were assigned a point value of one. The priority area was also split into three compartments within the 1.6–4.8 km and 4.8–8.0 km areas with a restriction that prohibited accumulation of ≥4 points within each compartment. To encourage field personnel to collect samples as close to the priority area as possible, no restriction was placed on number of points that could be collected within the 1-mi radius circle. The point objective for each priority area was ≥10.

Results

Captive Cervid Program

When the emergency legislation was passed in 2002, NCWRC estimated that there were 190 captive cervid facilities in the state and >1,970 cervids in captivity. Number of facilities in the state declined after captive cervids were voluntarily relinquished, inspections and buyouts were completed, and illegally-held cervids were confiscated. North Carolina currently has 89 captive cervid facilities (Fig. 1). Cervid species held in captivity included: fallow deer (*Dama dama*), white-tailed deer, red deer/wapiti/American elk (*Cervus elaphus*), sika deer (*Cervus nippon*), Indian munjtac deer (*Muntiacus muntjak*), axis deer (*Axis axis*), and reindeer (*Rangifer taran-*

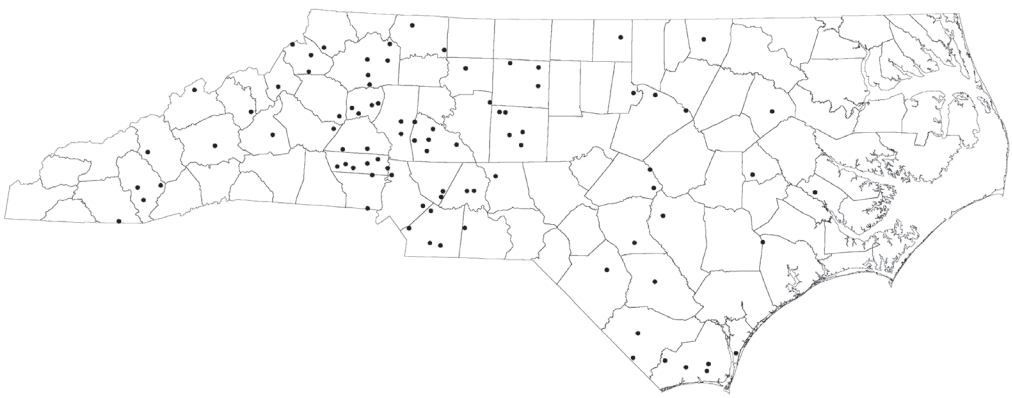

Figure 1. Locations of captive cervid facilities in North Carolina as of 1 August 2005.

Table 1. Results of semiannual inspections (2002–2005) of captive cervid facilities in North Carolina, as required by rules pertaining to holding cervids in captivity and chronic wasting disease surveillance.

	Compliance rates	Major deficiencies	Citations issued
Winter 2002–03	10%	Fence height/condition, pen capacity	0[a]
Winter 2003–04	57%	Tagging, fence height/condition	11
Winter 2004–05	82%	Pen capacity, tagging	3
Summer 2005b	83%	Pen capacity, tagging	2

a. Citations were not issued during winter 2002–03 inspections to allow licensees to become familiar with the 2002 captivity rule amendments promulgated by the N.C. Wildlife Resources Commission.

b. The first round of summer inspections began in May 2005. The first two summer inspections were deferred because of a delay in the initial tagging deadline.

dus), in order of abundance. Eighty-two percent of facilities ($N = 73$) held ≤20 cervids in captivity. Most facility operators in North Carolina kept cervids for family companions or breeding.

Major revisions of captivity rules included: (1) prohibition of importation and intrastate transportation of captive cervids until the United States Department of Agriculture approves a nationwide CWD monitoring program, (2) prohibition of issuing new licenses for holding cervids in captivity, (3) upgrading cervid enclosure requirements to restrict contact between captive and free-ranging cervids, (4) implementing of CWD testing, record-keeping, and dual tagging requirements, (5) pen size (number of captive cervids per acre of fenced area) restrictions, (6) creation of a licensing and inventory database was also created to track interstate and intrastate movements of captive cervids, catalog licensing information on captive cervid facilities, and document CWD test results of captive cervids, and (7) semiannual inspections of captive cervid facilities by the NCWRC and the NCDA&CS to monitor inventories, ensure compliance with cervid enclosure requirements, and monitor CWD testing protocols. Public outreach and education was also expanded to ensure public awareness of CWD, management efforts, and disease prevention in North Carolina (Betsill et al. 2002).

Facility Inspections.—Winter inspections began in December 2002 and continued annually. Summer inspections in 2003 were not completed to allow licensees additional time to tag captive cervids. Summer inspections in 2004 were not completed because of a delay in completion of winter 2003 inspections. Summer inspections first occurred in 2005. Compliance rates, major deficiencies recorded, and number of citations issued during inspections varied among years (Table 1).

CWD Testing Protocol.—Approximately 640 captive cervids have been tested for CWD since 2001 (Table 2). CWD has not been detected in any captive cervid samples completely evaluated.

Buyout Program.—Fifteen voluntary buyouts were completed, providing a CWD testing sample from 328 captive cervids. This sample constituted roughly 16% of the total captive cervids recorded in North Carolina when the program started. The buyout program ended 15 June 2004, and expenditures incurred by the NCWRC for purchase of animals totaled $247,850.

Table 2. Number of captive cervids tested for chronic wasting disease (CWD) per CWD surveillance of captive cervid facilities, 2001–2005 in North Carolina (as of 1 August 2005).

	2001	2002	2003	2004	2005	Total
Target animal					2	2
Buyout program			76	252		328
Voluntary relinquishment				11	9	20
Random death or slaughter	1	35	53	84	74	247
Settlement					9	9
Confiscation				3	31	34
Total	1	35	129	350	125	640

CWD Surveillance of Free-ranging White-tailed Deer

Historical Surveillance (1999–2001).—Surveillance activities were limited to samples collected from animals exhibiting clinical signs characteristic of CWD and animals collected for herd health evaluations (Table 3). Herd health evaluations were conducted by the Southeastern Cooperative Wildlife Disease Study on four federal properties and by NCWRC on one county property.

Priority Area Surveillance (2002).—Animals exhibiting clinical signs, collected in priority areas, examined during herd health evaluations, taken legally via depredation, and collected incidentally to other agency activities were tested for CWD (Table 3). Eighty of 140 samples collected were from priority areas. Ten samples were collected from 4 of the 17 priority areas, meeting surveillance objective. Samples were not collected from four priority areas because of relatively low deer densities, manpower constraints, or inability to obtain hunter-killed deer in the surveillance area. A range of 2.0–8.0 (*mean* = 4.4) samples was collected from the remaining nine priority areas.

Statewide Surveillance (2003).—Samples (N = 1,488) collected during 2003 included 1,002 quota and 486 nonquota samples (Fig. 2). While the statewide objective of 1,000 quota samples was achieved, the target number of quota samples for some individual counties was not achieved. However, the target number of quota samples for other counties was exceeded. The statewide surveillance objective was considered a success because sample apportionments to the county level were only to assist in determining approximately how many samples should be collected within each county.

Priority Area Surveillance (2004).—We collected 123 samples and 142 points (mean = 7.9 points per facility) from the 18 priority areas (Table 3). The sampling objective (minimum of 10 points per area) was met for 6 of the 18 priority areas. Number of points accrued around the remaining 12 priority areas ranged from 0.0–9.0 (mean = 5.7). No samples were collected from one priority area in the mountain region because of low deer densities and inability to obtain deer. However, 13 samples were collected from within the county where this priority area was located. A county sampling approach was also utilized for another priority area in the mountain region.

Figure 2. Locations of sample collections used in chronic wasting disease surveillance of free-ranging white-tailed deer in North Carolina, 2003.

Table 3. Number of free-ranging white-tailed deer tested for chronic wasting disease (CWD) per CWD surveillance in North Carolina, 1999–2004.

	1999	2000	2001	2002	2003	2004	Total
Clinical animal	3		4	24	21	19	71
Systematic sampling				80	1,488	123	1,691
Herd health evaluation		20	5	15			40
Depredation permit				8			8
Incidental sample				13		7	20
Total	3	20	9	140	1,488[a]	147[b]	1,807[a,b]

a. Twenty-one clinical animals collected in 2003 counted as either quota or nonquota samples and are also included in the systematic sampling total.

b. Two clinical animals were collected from priority areas in 2004 and are also included in the systematic sampling total.

While one sample with a value of two points was obtained in this priority area, 10 additional samples were also collected outside the priority area but within the county the priority area was located in. Additional samples were collected from animals displaying clinical symptoms and collected incidentally to other agency activities (Table 3).

Discussion and Management Implications

Although CWD was not detected in samples (N = 2,447) collected in North Carolina, implications and possible effects of an outbreak in the state remain significant. Wildlife management agencies and wildlife disease specialists across the United States must continue to research the etiology and epidemiology of CWD to develop effective control practices (Williams et al. 2002). Management agencies

should also implement effective disease monitoring and management programs to increase probability of disease detection. The NCWRC is concerned with implications of CWD to multiple stakeholders including hunters, wildlife viewers, other agencies, private-sector businesses, landowners, and operators of captive cervid facilities. With an estimated population of 1.1 million white-tailed deer (NCWRC, unpublished data) and >207,000 deer hunters in the state (IAFWA 2002), NCWRC is mindful of implications to deer hunting and deer hunters. North Carolina has a strong and long-held tradition associated with deer hunting. CWD and related concerns can result in a reduction in the value (i.e., quality) of deer hunting to deer hunters (Bishop 2004). One aspect of NCWRC actions related to CWD management is to maintain both quality and quantity of deer hunting opportunities in the state.

The impact of CWD on hunting participation can vary within and among states, but may not always be negative (Gigliotti 2004). As levels of CWD in a state increase, concerns by hunters and changes in their attitudes and behavior will likely also increase (Miller 2004). Changes in attitudes and behavior of hunters that result from CWD-related issues may result in decreased license sales, spatial displacement of deer hunting activity, a decline in hunting participation, decreased deer harvest, and decreased human consumption of harvested deer meat (Bishop 2004, Heberlein 2004, Miller 2004, Needham et al. 2004, Vaske et al. 2004). A decline in hunting participation can result in a decrease in operating revenue. State wildlife agency efforts to address CWD issues concomitant with decreasing license revenue could result in a diversion of agency funds from existing management programs to CWD monitoring and eradication (Heberlein 2004, Williams et al. 2002).

Economic impacts resulting from CWD being diagnosed in a state are largely driven by uncertainty and are complicated, diverse, and often difficult to measure (Bishop 2004, Seidl and Koontz 2004). There can be significant (i.e., millions of dollars annually) impacts to a state's economy, especially to those segments relating to hunting and hunters, and these impacts can increase in significance as prevalence of CWD increases (Bishop 2004). If CWD becomes prevalent in a state and results in decreased hunting or hunting license sales, wildlife agencies may consider mandatory CWD testing to maintain adequate levels of hunting participation (Bishop 2004, Gigliotti 2004, Vaske et al. 2004). The NCWRC encourages North Carolinians hunting cervids outside of our state to re-enter the state with only: (1) meat that is boned out, processed and wrapped, (2) portions of the carcass that have no central nervous system tissue attached, (3) clean hides without attached heads, (4) clean skull plates with attached antlers, (5) teeth, or (6) finished taxidermy mounts (NCWRC 2002).

We agree with Gigliotti (2004), Heberlein (2004), and Williams et al. (2002) that public outreach; coordination among state agencies whose purviews are wildlife management, livestock management, and disease risk assessment and control; complete stakeholder involvement; applied research; and adequate and complete human dimensions evaluations are critical to managing the biological, economic, and social aspects of CWD even in a state like North Carolina where no positive diagnoses have been made. Results from states in which CWD has been diagnosed substantiate the importance of these biological and socioeconomic factors and the need for the

NCWRC to continue efforts to maintain a CWD-free status in North Carolina. In the future, North Carolina should consider expanding CWD surveillance of captive and free-ranging cervids.

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Literature Cited

Betsill, C.W., D.T. Cobb., K.E. Douglass, E.B. Gillis, B.G. Gunn, H.T. Hall, J.S. Osborne, K.A. Pipkin, V.E. Stanford, P.W. Sumner, and R.C. Wilson. 2002. Chronic wasting disease: strategic plan for North Carolina. Staff report. North Carolina Wildlife Resources Commission.

Bishop, R.C. 2004. The economic impacts of chronic wasting disease (CWD) in Wisconsin. Human Dimensions of Wildlife 9:181–192.

Cannon, R.M and R.T. Roe. 1982. Livestock disease surveys: a field manual for veterinarians. Australian Government Publishing Service, Canberra.

Gigliotti, L.M. 2004. Hunters' concerns about chronic wasting disease in South Dakota. Human Dimensions of Wildlife 9:233–235.

Heberlein, T. A. 2004. "Fire in the Sistine Chapel": how Wisconsin responded to chronic wasting disease. Human Dimensions of Wildlife 9: 165–179.

International Association of Fish and Wildlife Agencies (IAFWA). 2002. Economic importance of hunting in America. Washington, D.C.

Miller, C.A. 2004. Deer hunter participation and chronic wasting disease in Illinois: an assessment at time zero. Human Dimensions of Wildlife 9:237–239.

Miller, M.W., E.S. Williams, N.T. Hobbs, and L.L. Wolfe. 2004. Environmental sources of prion transmission in mule deer. Emerging Infectious Diseases 10:1003-1006.

Needham, M.D., J.J. Vaske, and M.J. Manfredo. 2004. Hunters' behavior and acceptance of management actions related to chronic wasting disease in eight states. Human Dimensions of Wildlife 9:222–231.

North Carolina Wildlife Resources Commission (NCWRC). 2002. Chronic wasting disease: information for the hunting public. Raleigh, North Carolina.

Seidl, A.F. and S.R. Koontz. 2004. Potential economic impacts of chronic wasting disease in Colorado. Human Dimensions of Wildlife 9:241–245.

Vaske, J.J., N.R. Timmons, J. Beaman, and J. Petchenik. 2004. Chronic wasting disease in Wisconsin: hunter behavior, perceived risk, and agency trust. Human Dimensions of Wildlife 9:193–209.

Williams, E.S. and M.W. Miller. 2002. Chronic wasting disease in deer and elk in North America. OIE Revue Scientifique et Technique 21: 305–316.

_____, _____, T.J. Kreeger, R.H. Kahn, and E.T. Thorne. 2002. Chronic wasting disease of deer and elk: a review with recommendations for management. Journal of Wildlife Management 66:551–563.