

Hunters' Behavior and Acceptance of Management Actions Related to Chronic Wasting Disease in Eight States

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The impacts of chronic wasting disease (CWD) on hunters' behavior and beliefs about acceptable management actions are not clearly understood. This article presents findings from an initial phase of a multi-stage, multi-state effort to address these knowledge gaps. Data were obtained from mail surveys (n=659) of resident and nonresident deer hunters in eight states and elk hunters in three states. Hunters were presented with hypothetical situations of increasing: (1) CWD prevalence (all eight states), and (2) human health risks (two states). Logistic regression equations estimated that at current prevalence levels in some states, 3% (residents) to 5% (nonresidents) of hunters would stop hunting deer/elk in their state. If 50% of the deer or elk across the state were infected, approximately 42% (residents) and 54% (nonresidents) would stop hunting deer/elk in their state. In hypothetical situations where a hunter died from CWD at this prevalence level, the percentage was 68%. Potential for conflict indices (PCI) showed that as prevalence and human health risks increased, acceptability of testing and lethal management

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increased and acceptability of allowing CWD to take its natural course decreased.

Keywords *chronic wasting disease, hunting, risk behavior, wildlife management, potential for conflict index*

Introduction

Chronic wasting disease (CWD) has generated considerable concern among wildlife managers, biologists, and other stakeholders (Schauber & Woolf, 2003; Williams, Miller, Kreeger, Kahn, & Thorne, 2002). The disease is a fatal transmissible spongiform encephalopathy (TSE) found in mule deer (*Odocoileus hemionus*), white-tailed deer (*Odocoileus virginianus*), and Rocky Mountain elk (*Cervus elaphus nelsoni*) (Spraker et al., 1997). Infected animals exhibit excessive salivation, loss of body functions, and emaciation (Williams et al., 2002). CWD is similar to other TSE diseases such as mad cow disease, scrapie in sheep, and Creutzfeldt-Jakob disease in humans (Gross & Miller, 2001; McKintosh, Tabrizi, & Collinge, 2003).

CWD was first detected among captive deer and elk in the 1960s and 1970s (Williams & Young, 1980, 1982) and free-ranging deer and elk in the 1980s and 1990s (Spraker et al., 1997) in both Colorado and Wyoming. CWD has also been discovered in free-ranging herds in Illinois, Nebraska, New Mexico, Saskatchewan, South Dakota, Utah, and Wisconsin (Belay et al., 2004; Beringer, Hansen, Millspaugh, & Meyer, 2003; Joly et al., 2003). Although research has been conducted on the pathology, epidemiology, transmission, and clinical signs of CWD (see Belay et al., 2004; Williams & Miller, 2002; Williams et al., 2002 for reviews), little is known about: (1) the extent to which prevalence and potential human health risks of CWD influence individuals' decisions to stop hunting, and (2) hunters' beliefs about strategies for managing the disease. This article presents findings that address both of these knowledge gaps.

The Human Dimensions of CWD

In North America, hunting participation rates have declined (Brown, Decker, Siemer, & Enck, 2000; Heberlein & Thomson, 1996; Li, Zinn, Barro, & Manfredo, 2003; Miller & Vaske, 2003) and wildlife agencies are concerned that this decline could be exacerbated by hunters' perceptions of potential unknown risks associated with CWD (Schauber & Woolf, 2003; Williams et al., 2002). Research has shown that hunting participation in some states has already decreased as a result of CWD (Bishop, 2004; Heberlein, 2004; Vaske, Timmons, Beaman, & Petchenik, 2004b).

A decline in hunting participation due to CWD is problematic for several reasons. First, decreased hunting directly reduces wildlife agencies' revenues from license sales that support operating costs (Fix, Pierce, Manfredo, & Sikorowski,

1998; Mehmood, Zhang, & Armstrong, 2003; Miller & Vaske, 2003). Wildlife management programs (e.g., pheasant stocking) are indirectly impacted when agency funds are diverted to address CWD (Heberlein, 2004). Given that hunting is used to control deer and elk populations, a decline in participation interferes with an agency's ability to manage game species (Backman & Wright, 1993; Enck, 1996).

Second, deer and elk hunting have a culturally significant history in North America (Decker, Brown, & Siemer, 2001; Herman, 2003; Lamar & Donnell, 1987). Strong hunting traditions exist among friends and families in many rural communities (Heberlein & Thomson, 1996; Li et al., 2003). For example, hunting is so ingrained in Wisconsin's culture that many schools and businesses close for the traditional 9-day gun deer hunting season in November (Heberlein, 2004). CWD has the potential to severely impact this cultural tradition and the social and economic stability of the communities that depend on hunting (Bishop, 2004; Heberlein, 2004). Direct economic impacts would be significant to many rural businesses (e.g., motels, restaurants, retail stores) and the lack of turnover spending in these communities would impact residents (Bishop, 2004; Loomis & Walsh, 1997; Seidl & Koontz, 2004).

Third, declining hunting participation due to CWD could erode public support for wildlife agencies and their ability to manage the resource (Fulton & Hundertmark, 2004; Miller & Vaske, 2003). A decrease in the number of hunters weakens the traditional constituent base, which results in a loss of public support for hunting (Mehmood et al., 2003).

Finally, hunters themselves could be impacted by a decrease in hunting participation. Individuals who stop hunting due to CWD concerns could influence their hunting partners not to hunt. With increased fear of CWD, hunters might substitute deer and/or elk hunting with alternative types of hunting (e.g., pheasant hunting) in other areas, which increases the demand on different hunting species and locations (Vaske, Donnelly, & Shelby, 1990).

Conceptual Foundation and Research Questions

Given these potential consequences of CWD, recent research has focused on the extent to which hunters might change their behavior in response to CWD (Gigliotti, 2004; Miller, 2003, 2004; Petchenik, 2003; Vaske, Needham, Manfredo, Newman, & Petchenik, 2004a; Vaske et al., 2004b). Most studies have presented hunters with hypothetical situations depicting manipulated levels of CWD prevalence (e.g., 1% or 5% deer or elk infected) and other issues related to CWD (e.g., the availability of testing). Respondents reported their behavioral intentions for each situation (e.g., continue to hunt, stop hunting). Studies in South Dakota (Gigliotti, 2004) and Wisconsin (Petchenik, 2003; Vaske et al., 2004a, 2004b) have shown that between 10% and 20% of hunters would stop hunting in their unit if 5% to 20% of its deer were infected. Miller (2004) reported that 5% of Illinois

deer hunters would stop hunting if CWD was ever detected in or adjacent to the county where they hunted. Over 80% of Illinois deer hunters indicated that the discovery of CWD in the state did not influence their hunting participation or decision to hunt (Miller, 2003).

These studies manipulated relatively minor CWD prevalence levels. Consequently, most hunters reported that they would not dramatically change their hunting behavior. Disease-related research, however, has identified *two* main predictors of human behavior in response to diseases: (1) high prevalence and distribution of a disease, and (2) perceived human health consequences of a disease (Amnon, 2002; Freimuth, Edgar, & Hammond, 1987; Sugihantono et al., 2003; Wang, Tsai, Huang, & Hong, 2003; Yates, 1992). For example, when the consequences (e.g., high prevalence in a population, severe human health risks) of a disease such as HIV/AIDS were understood, individuals were less likely to engage in behavior such as unprotected sex (Amnon, 2002; Sugihantono et al., 2003).

Although studies (Gigliotti, 2004; Miller, 2004; Petchenik, 2003; Vaske et al., 2004a, 2004b) have examined the influence of relatively low CWD prevalence levels on hunters' behavior, little is known about how higher CWD prevalence and potential human health risks related to the disease could influence hunters' behavior. CWD prevalence in some free-ranging populations has been estimated at over 15% (Gross & Miller, 2001; Miller et al., 2000; Wolf et al., 2002), but higher prevalence (e.g., 90%) has been noted in captive populations (Williams & Young, 1980). No known cases of human disease have been directly linked to CWD (Belay et al., 2004; World Health Organization, 2000), but research has suggested that this risk cannot be dismissed with absolute certainty (Belay et al., 2004; Raymond et al., 2000). Laboratory experiments, for example, have shown that human susceptibility to CWD is very low due to the lack of conversion compatibility of the prion strain (i.e., infectious proteins without associated nucleic acids) believed to cause CWD (Raymond et al., 2000). Interspecies transmission of the disease to humans may occur, but only rarely and inefficiently (Raymond et al., 2000).

Given the similarities between CWD and other TSE diseases that can cause human death (e.g., Creutzfeldt-Jakob disease) (McKintosh et al., 2003), the potential for human susceptibility to CWD (Belay et al., 2004; Raymond et al., 2000), and the possibility for CWD in deer and elk populations to reach high prevalence levels (Gross & Miller, 2001; Miller et al., 2000; Williams & Young, 1980), it is unclear how hunters will respond to the disease if conditions change.

This article addresses three primary research questions. First, to what extent will various hypothetical degrees of CWD prevalence and distribution influence hunters' willingness to continue hunting in their state? Second, to what extent will hypothetical human health risks associated with CWD influence hunters' willingness to continue hunting in their state? Third, to what extent will hypothetical degrees of CWD prevalence, distribution, and

human health risk influence hunters' acceptance of lethal and non-lethal strategies for managing CWD in deer and elk?

Methods

Data Collection

Data for this article represent the initial phase of a larger multi-stage, multi-state effort designed to understand hunters' responses to CWD. The study is supported by the Western Association of Fish and Wildlife Agencies (WAFWA). Data were obtained from mail surveys sent to resident and nonresident deer hunters in eight states (Arizona, Colorado, Nebraska, North Dakota, South Dakota, Utah, Wisconsin, Wyoming) and elk hunters in three states (Colorado, Utah, Wyoming), yielding a total of 22 strata. To date, CWD has been detected in free-ranging deer and/or elk herds in each of these states except Arizona and North Dakota. The study population consisted of hunters (18 years of age or older) who purchased a resident or nonresident license to hunt deer or elk in 2002. Random samples of hunter addresses were obtained from the wildlife/game and fish government agency of each participating state.

The surveys were developed through a cooperative effort between representatives of each wildlife/game and fish agency and researchers at Colorado State University. Survey design and administration followed a modified version of the procedures outlined by Dillman (2000). Three mailings were used to administer the survey beginning in November 2003. Hunters first received a survey, pre-paid postage return envelope, and cover letter explaining the study and requesting their participation. Non-respondents were mailed a postcard reminder two weeks after the initial mailing. A second complete mailing (i.e., survey, pre-paid postage return envelope, cover letter) was sent to non-respondents two weeks after the postcard reminder. Surveys were mailed to a total of 1,430 hunters (65 hunters in each of the 22 strata). Across all states and strata, 71 surveys were undeliverable (e.g., incorrect addresses, moved) and 659 completed mail surveys were returned, yielding a 49% response rate (659/1,430–71). Among the strata, response rates ranged from 39% (Utah resident deer hunters) to 64% (Nebraska nonresident deer hunters).

To check for potential non-response bias, respondents who completed the mail survey were compared against those who did not return the survey. A random sample of 147 non-respondents was telephoned in February 2004 and asked a subset of questions from the mail survey. Responses were not statistically different ($p > .05$) between mail survey respondents and non-respondents. The Cramer's V and point-biserial correlation (r_{pb}) effect sizes were less than .10, indicating only minimal (Vaske, Gliner, & Morgan, 2002) or weak (Cohen, 1988) differences between the two groups. Non-response bias was thus not considered to be a problem and the data were not weighted.

Analysis Variables

Independent variables

Computer generated maps were used to depict hypothetical situations of varying CWD human health risks and increasing levels of CWD prevalence among deer or elk in three zones across each state (Figure 1). In six of the states (Colorado, Nebraska, South Dakota, Utah, Wisconsin, Wyoming), zone A represented the area where the disease had been detected in free-ranging populations and had the highest prevalence. For Arizona and North Dakota, zone A represented the most likely region for CWD to be detected, if ever. The decision of where to situate zone A was made by each wildlife/game and fish agency. For all state maps, zones B and C were similar in size. For most states, CWD had not been detected in free-ranging deer or elk in zone C, which was considered by each agency to be the least likely location for high rates of CWD infection to occur. All three zones for each state were based on hunt management units.

The maps in the surveys depicted four separate hypothetical situations of increasing CWD prevalence and distribution: (1) 10% prevalence in zone A, 0% in zones B and C; (2) 30% in zone A, 10% in zone B, 0% in zone C; (3) 50% in zone A, 30% in zone B, 10% in zone C; and (4) 50% in all three zones (i.e., across the entire state).

Surveys for two states (South Dakota and Wisconsin, $n = 123$) included four additional hypothetical situations related to prevalence levels and human health risks: (1) 10% prevalence in zone A, 0% in zones B and C, and “CWD can be transmitted to humans by eating infected deer meat, posing a potential health risk;” (2) 10% prevalence in zone A, 0% in zones B and C, and “a hunter in the state has died from eating CWD infected deer meat;” (3) 50% prevalence in all three zones and “CWD can be transmitted to humans by eating infected deer meat, posing a potential health risk;” and (4) 50% prevalence in all three zones and “a hunter in the state has died from eating CWD infected deer meat.” These situations reflect the two main predictors of disease-related behavior—disease prevalence and perceived human health risks (Amnon, 2002; Sugihantono et al., 2003; Yates, 1992).¹ To emphasize the hypothetical nature of these situations, survey respondents were assured that the situations were “imaginary” (hypothetical) and did not necessarily reflect current conditions or consequences to humans.

The independent variables measured with these situations were: (1) prevalence in zone A, (2) prevalence in zone B, (3) prevalence in zone C, and (4) a human health risk dummy variable coded as 0 “no effect of CWD on human health” and either 1 “CWD transmissible to humans” or “hunter death from CWD” (South Dakota and Wisconsin only). A residency dummy variable coded as 0 “nonresident hunter” and 1 “resident hunter” was also measured in the surveys.

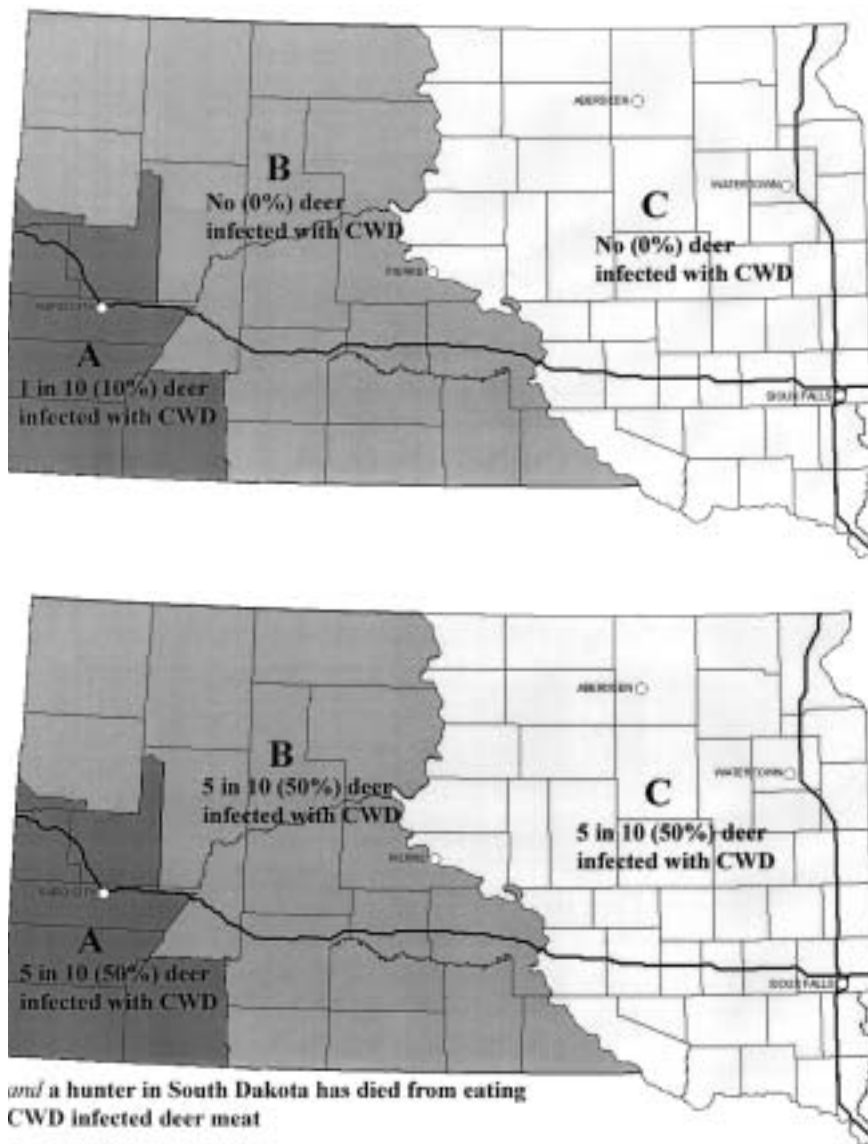


FIGURE 1 Sample maps depicting hypothetical CWD prevalence, distribution, and human health risks.

Note. These maps were used in the surveys for South Dakota and are provided here as an example. For six of the states, zone A represented the area where CWD had already been detected and had the highest CWD prevalence. For Arizona and North Dakota, zone A represented the opinions of the state wildlife/game and fish agencies regarding the most likely region for CWD to be first detected, if ever. All three zones were based on hunt management units, which often transect county borders (thin lines) and interstate highways (thick lines).

Dependent variables

To measure the extent to which CWD prevalence, distribution, and human health risks influence hunters' willingness to continue hunting in their state, respondents evaluated each hypothetical situation and indicated if they would: (1) hunt deer in the zone in the state that they hunt deer in most often; (2) hunt deer in the state, but switch to a different zone; (3) give up deer hunting in the state, but hunt deer in another state; or (4) give up deer hunting altogether. The respective state name was provided in the response items for each survey and elk hunting was substituted for deer hunting in surveys of elk hunters. For analysis purposes, the first two response items were collapsed into one category labeled 0 "still hunt deer/elk in the state;" the last two items were recoded into 1 "stop hunting deer/elk in the state."

Following each hypothetical situation, hunters also rated their acceptance of four possible lethal and non-lethal management actions that their state wildlife/game and fish agency might take. The two non-lethal actions were: (1) take no action and allow CWD to take its natural course, and (2) continue to test deer/elk for CWD. The two lethal actions were: (1) use *trained agency staff*, and (2) use *hunters* to dramatically reduce herds in affected zones to lower the potential for CWD spreading. Respondents rated each action for each situation on a 7-point scale ranging from -3 "highly unacceptable" to +3 "highly acceptable."

Data Analysis

Frequency distributions of hunters' reported behavioral intentions (i.e., still hunt deer/elk in the state, stop hunting deer/elk in the state) for each of the four situations of increasing CWD prevalence and distribution were examined first. Bivariate analyses (e.g., χ^2) compared resident and nonresident hunters' responses for each situation. Effect size measures (e.g., ϕ) were reported where appropriate. Frequency distributions of South Dakota and Wisconsin hunters' reported behavioral intentions for the four additional situations related to CWD prevalence and human health risks were also examined. Four binary logistic regression equations were used to estimate the percentage of hunters that would stop hunting deer/elk in their state as a function of the independent variables (i.e., prevalence in each zone, human health risks, residency). Hunters' acceptance of the four management actions for each hypothetical situation was analyzed using the potential for conflict index (PCI) and a related graphic approach for communicating the results (see Manfredi, Vaske, & Teel, 2003 for a review). The PCI ranges from 0 to 1; a large PCI indicates a high potential for conflict regarding the acceptability of a management action.

Results

Descriptive and Bivariate Findings

In total, 5% of the hunters reported that they would stop hunting deer/elk in the state if 10% of the deer or elk in zone A and 0% in the rest of the state (zones B and C) were infected with CWD (Table 1). This prevalence level is consistent with current conditions in parts of some states (e.g., Colorado, Wyoming). The percentage of respondents that would stop hunting deer/elk in the state increased as prevalence and distribution increased. For example, if CWD prevalence was 50% in zone A, 30% in zone B, and 10% in zone C, 32% of hunters would stop hunting deer/elk in the state. If 50% of the deer or elk across the entire state were infected, 49% of hunters reported that they would stop hunting deer/elk in the state.² Across all eight states, a similar proportion of respondents hunted most often in zone A (30%), B (33%), or C (37%) in 2002.

TABLE 1 Resident and Nonresident Hunters' Reported Behavioral Intentions for Each Situation Related to CWD Prevalence

CWD prevalence situations	Sample size	Behavioral intention ¹		χ^2 -value	p-value	ϕ
		Still hunt in state	Stop hunting in state			
10% in A, 0% in B, 0% in C				0.35	.552	.024
Resident hunters	300	95	5			
Nonresident hunters	324	96	4			
Total	624	96	5			
30% in A, 10% in B, 0% in C				2.36	.125	.061
Resident hunters	301	89	11			
Nonresident hunters	319	85	15			
Total	620	87	13			
50% in A, 30% in B, 10% in C				10.68	<.001	.131
Resident hunters	300	75	25			
Nonresident hunters	320	63	38			
Total	620	68	32			
50% in A, 50% in B, 50% in C				13.48	<.001	.147
Resident hunters	302	59	41			
Nonresident hunters	321	44	56			
Total	623	51	49			

¹ Cell entries are percentages (%).

The responses from residents and nonresidents were statistically different ($\chi^2 = 10.68$ to 13.48 , $df = 1$, $p < .001$, $\phi = .13$ to $.15$, Table 1) on two of the four CWD prevalence situations (50% in zone A, 30% in zone B, 10% in zone C; 50% in all three zones). When CWD prevalence was high (e.g., 30% to 50% in an area), significantly more nonresident hunters reported that they would stop hunting deer/elk in the state. For example, if prevalence was 50% across the entire state, 41% of residents and 56% of nonresidents would stop hunting deer/elk in the state. For situations of relatively low to moderate CWD prevalence (e.g., no areas with 50%), slightly more nonresident hunters would stop hunting deer/elk in the state, but these differences were minimal ($\phi = .02$ to $.06$) and statistically insignificant ($\chi^2 = .35$ to 2.36 , $df = 1$, $p = .125$ to $.552$).

For South Dakota and Wisconsin deer hunters who responded to the four additional hypothetical situations related to CWD prevalence and human health risks, 18% reported that they would stop hunting deer in the state if 10% of the deer in zone A were infected with CWD, no deer in the rest of the state were infected, and CWD was proven to be transmissible to humans (Table 2). If a hunter died from CWD at this prevalence level, 23% of respondents would stop hunting deer in the state. If 50% of the deer across the entire state were infected and CWD was transmissible to humans, 60% of hunters would stop hunting deer in the state. If a hunter died from CWD at this high prevalence level, 65% of hunters would stop hunting deer in the state.

TABLE 2 South Dakota and Wisconsin Hunters' Reported Behavioral Intentions for Each Situation Related to CWD Prevalence and Potential Human Health Effects

CWD human health effects and prevalence situations	Sample size	Behavioral intention ¹	
		Still hunt in state	Stop hunting in state
10% in A, 0% in B, 0% in C and CWD transmissible to humans	114	83	18
10% in A, 0% in B, 0% in C and human death from CWD	114	77	23
50% in A, 50% in B, 50% in C and CWD transmissible to humans	116	41	60
50% in A, 50% in B, 50% in C and human death from CWD	115	35	65

¹ Cell entries are percentages (%).

Logistic Regression Equations for Predicting Hunters' Behavior

The first binary logistic regression equation examined the influence of CWD prevalence and distribution on the probability that hunters will stop hunting deer/elk in the state. This analysis took the form of the following prediction equation:

$$\ln(\text{odds}) = -3.789 + .073(P_a) - .033(P_b) + .035(P_c) \tag{1}$$

where P_a = CWD prevalence in zone A, P_b = prevalence in zone B, and P_c = prevalence in zone C (Nagelkerke $R^2 = .24$). The calculation, $\text{odds} = \exp^{\ln(\text{odds})}$, gives the predicted odds of hunters stopping deer/elk hunting in the state. Following this, $\text{odds}/(1 + \text{odds})$, estimates the percentage of hunters that will stop hunting deer/elk in the state. Table 3 and Figure 2 show that the percentage of hunters that will stop hunting deer/elk in the state increases as prevalence and distribution increase. Results suggest that 5% (10% CWD prevalence in zone A, 0% in zones B and C), 13% (30% in zone A, 10% in zone B, 0% in zone C), 32% (50% in zone A, 30% in zone B, 10% in zone C), and 49% (50% CWD prevalence across state) will stop hunting in the state.

TABLE 3 Odds and Probabilities that Resident and Non-resident Hunters will Stop Hunting Deer/Elk in the State for Each Situation Related to CWD Prevalence

CWD prevalence situations	Odds	Probability
10% in A, 0% in B, 0% in C		
Resident hunters	.035	.034
Nonresident hunters	.058	.054
Total	.047	.045
30% in A, 10% in B, 0% in C		
Resident hunters	.109	.099
Nonresident hunters	.178	.151
Total	.145	.127
50% in A, 30% in B, 10% in C		
Resident hunters	.346	.257
Nonresident hunters	.563	.360
Total	.459	.315
50% in A, 50% in B, 50% in C		
Resident hunters	.725	.420
Nonresident hunters	1.181	.541
Total	.962	.490

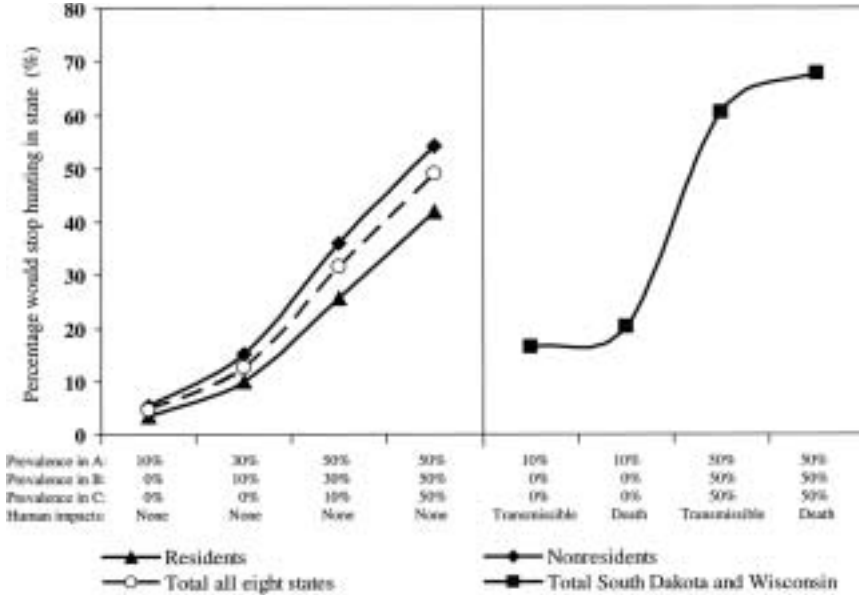


FIGURE 2 Summary of percentage of hunters that would stop hunting deer/elk in the state for each situation.

The second logistic regression equation explored the effect of CWD prevalence and distribution on the probability that resident or nonresident hunters will stop hunting deer/elk in the state. This analysis resulted in the following prediction equation:

$$\ln(\text{odds}) = -3.584 + .073(P_a) - .033(P_b) + .035(P_c) - .488(R) \quad (2)$$

where R = residency dummy variable of 0 “nonresident hunter” and 1 “resident hunter.” This model ($-2LL=2316.01$, Nagelkerke $R^2=.25$) showed a significantly ($\chi^2=22.58$, $df=1$, $p<.001$) better fit over the initial model (Equation 1, $-2LL=2338.59$). The percentage of resident or nonresident hunters that will stop hunting deer/elk in the state increases as prevalence and distribution increase (Table 3, Figure 2). For all situations, however, a greater percentage of non-residents will stop hunting deer/elk in the state. At the lowest prevalence level examined (10% in zone A, 0% in zones B and C), for example, nonresident hunters are almost twice as likely to stop hunting deer/elk in the state (5%) compared to residents (3%). If 50% of the deer or elk across the entire state are ever infected with CWD, 42% and 54% of resident and nonresident hunters can be expected to stop hunting deer/elk in the state, respectively.

The final two logistic regressions examined the influence of CWD prevalence, distribution, and potential human health risks (i.e., transmissible to humans, hunter death from CWD) on the probability that South Dakota or Wisconsin deer hunters will stop hunting deer in their state. The two prediction equations were:

$$\ln(\text{odds}) = .753 - .265(P_a) + .433(P_b) - .180(P_c) + .271(T) \tag{3}$$

$$\ln(\text{odds}) = .320 - .241(P_a) + .403(P_b) - .168(P_c) + .720(D) \tag{4}$$

where T =dummy variable of 0 “no effect of CWD on human health” and 1 “CWD transmissible to humans” (Equation 3, Nagelkerke $R^2=.28$), and D =dummy variable of 0 “no effect of CWD on human health” and 1 “hunter death from CWD” (Equation 4, Nagelkerke $R^2=.29$). Table 4 and Figure 2 indicate that if CWD is ever shown to be transmissible to humans and 10% of the deer in zone A are infected with the disease, 16% of hunters will stop hunting deer in South Dakota or Wisconsin. This percentage increases to 20% if a hunter ever dies from CWD and this prevalence level exists. Should this prediction equation hold for larger samples of South Dakota and Wisconsin hunters to be obtained in future phases of this study, the following high attrition rates can be expected: (1) if CWD is ever shown to be transmissible to humans and 50% of the deer in South Dakota or Wisconsin are infected with the disease, 60% of hunters will stop hunting deer in these states; and (2) the percentage increases to 68% if a hunter ever dies from CWD and 50% of the deer across the entire state are infected with CWD.

TABLE 4 Odds and Probabilities that South Dakota or Wisconsin Hunters will Stop Hunting Deer in the State for Each Situation Related to CWD Prevalence and Potential Human Health Effects

CWD human health effects and prevalence situations	Odds	Probability
10% in A, 0% in B, 0% in C and CWD transmissible to humans	.197	.164
10% in A, 0% in B, 0% in C and human death from CWD	.254	.203
50% in A, 50% in B, 50% in C and CWD transmissible to humans	1.528	.604
50% in A, 50% in B, 50% in C and human death from CWD	2.096	.677

Acceptability of Management Actions in Response to CWD

Non-lethal actions

Across all hypothetical situations of CWD prevalence, distribution, and human health risk, respondents believed that agency testing of deer and elk for CWD is moderately to highly *acceptable* (Figure 3). Given the small (PCI = .04 to .08) potential for conflict index (PCI ranges from 0 to 1, Manfredi et al., 2003) for each situation, this management action revealed virtually no potential for conflict among hunters. Conversely, hunters felt that it would be moderately to highly *unacceptable* for agencies to take no action and allow CWD to take its natural course. This strategy was unacceptable for all situations.

Lethal actions

Hunters, on average, believed that it would be slightly to moderately acceptable for the agencies to allow *hunters* to dramatically reduce deer and/or elk populations in affected zones to lower the potential for CWD spreading (Figure 4). Hunters' acceptance of this strategy slightly increased as prevalence

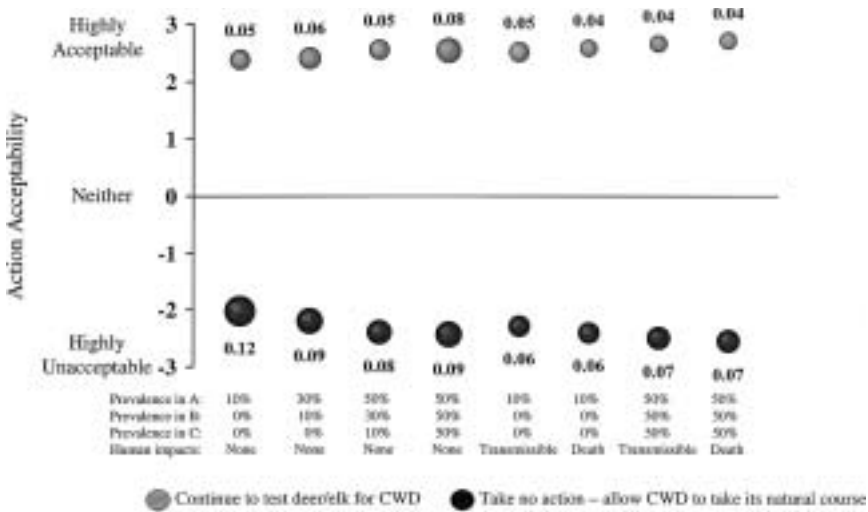


FIGURE 3 Hunters' acceptance of the state agencies using non-lethal management actions.

Note. Numbers for each bubble are the potential for conflict index (PCI). The center of each bubble is the mean acceptability of the situation. Results for situations with no human impacts represent the entire sample; results for situations where CWD may be transmitted to humans or cause a hunter death represent South Dakota and Wisconsin respondents. Residents' and nonresidents' acceptance was not significantly different for all situations (after Bonferroni correction); effect sizes were minimal ($r_{pb} = .002$ to $.097$).

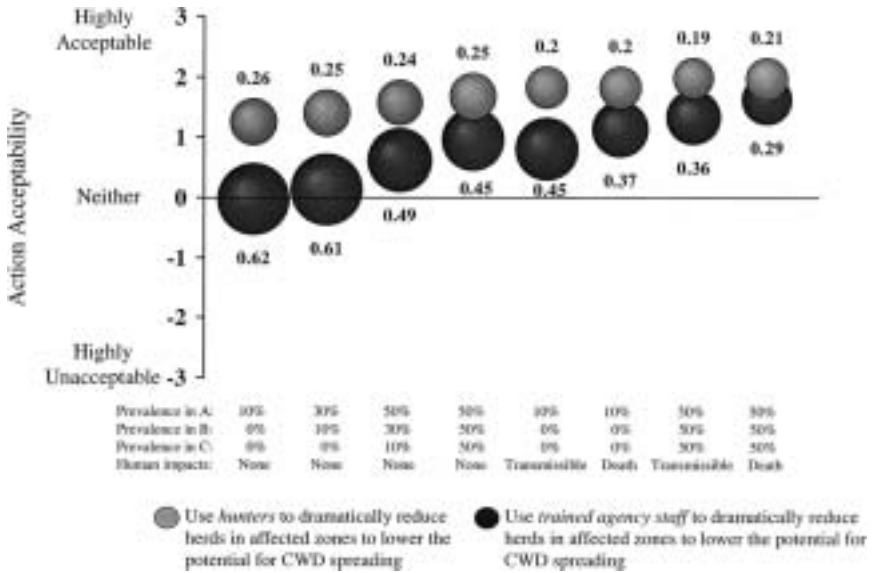


FIGURE 4 Hunters' acceptance of the state agencies using lethal management actions.

Note. Numbers for each bubble are the potential for conflict index (PCI). The center of each bubble is the mean acceptability of the situation. Results for situations with no human impacts represent the entire sample; results for situations where CWD may be transmitted to humans or cause a hunter death represent South Dakota and Wisconsin respondents. Residents' and nonresidents' acceptance was not significantly different for all situations (after Bonferroni correction); effect sizes were minimal ($r_{pb} = .003$ to $.107$).

and/or human health risks increased. Conversely, hunters' acceptance of allowing *trained agency staff* to reduce deer and/or elk populations in affected zones was close to neutral for situations of relatively low or moderate CWD prevalence (e.g., no areas with 50%). Given current conditions in some states, there was no clear majority agreement among hunters regarding this management action. Acceptability of this action, however, increased dramatically as prevalence and/or human health risks increased.

Given the larger PCI values, these two lethal management actions (PCI = .19 to .62) were likely to be more controversial than the two non-lethal actions (PCI = .04 to .12). In addition, the indices suggested that using trained agency staff to reduce herds in affected zones to lower the possibility of CWD spreading (PCI = .29 to .62) has a greater potential for conflict among hunters than allowing hunters themselves (PCI = .19 to .26) to perform this task (i.e., the PCI and bubbles are bigger). Both of these lethal management actions, however, have a lower potential for conflict among hunters as CWD prevalence, distribution, and human health risks increase.

Discussion

Implications for Human Dimensions Research

This article examined the extent to which potential CWD prevalence, distribution, and human health risks could influence deer and elk hunters': (1) willingness to continue hunting in their state, and (2) acceptance of strategies for managing CWD. Unlike recent human dimensions research on CWD (Gigliotti, 2004; Miller, 2003, 2004; Petchenik, 2003; Vaske et al., 2004a, 2004b), this article demonstrated that potential conditions related to the disease could influence a large proportion (e.g., over 60%) of deer and elk hunters to change their hunting behavior.

It is important, however, to be clear about the population represented in this article. Given the small sample size from each state, generalizations can only be made about the combined deer and elk hunter population across all eight participating states. Although ancillary analyses revealed no significant differences in responses among the eight states and between deer and elk hunters, this could be a function of inadequate sample sizes for these subgroups. Future phases of this study will include a more extensive follow-up in each of the participating states to examine differences among the states and between resident and nonresident deer and elk hunters.

In addition, the four additional hypothetical situations related to human health risks (i.e., CWD transmissible to humans, hunter death from CWD) were only included in the surveys for South Dakota and Wisconsin ($n = 123$). Results from these situations are tentative, require replication, and primarily serve the development of hypotheses for future phases of this study.

Implications for Managers

Findings presented here showed that at current CWD prevalence levels in some states, approximately 5% of hunters will stop hunting deer/elk in their state. This is consistent with other studies (Gigliotti, 2004; Miller, 2004; Petchenik, 2003; Vaske et al., 2004a, 2004b) and implies that almost all hunters will continue hunting deer or elk in their state if CWD conditions do not dramatically worsen. From a management standpoint, this suggests that agencies will likely suffer only minor declines in revenue from license sales if CWD conditions do not worsen.

Results, however, suggest more serious potential ramifications of CWD. Research has shown that although it is unlikely to occur, CWD can reach higher prevalence levels in deer and elk populations (Gross & Miller, 2001; Miller et al., 2000; Williams & Young, 1980) and the potential for human susceptibility to CWD may exist (Belay et al., 2004; Raymond et al., 2000). If CWD prevalence among deer or elk ever increases to 50% across a state, 49% of hunters will stop hunting deer/elk in the state. Based on the findings from South Dakota and Wisconsin, 60% to 68% of hunters will stop hunting deer/elk in their state if this

prevalence level exists and CWD is shown to be transmissible to humans or cause human death. Even at current prevalence levels (e.g., 10%) in parts of some states (e.g., Colorado, Wyoming), 16% to 20% of hunters will stop hunting deer/elk in their state if CWD affects humans or causes human death.

These findings suggest that if CWD prevalence increases dramatically, deer and/or elk hunting participation will substantially decrease in several states. If high levels of prevalence are combined with threats to human health, the decline could be even greater. This could have compounding and catastrophic effects on revenues for wildlife agencies, financial and logistical support for wildlife programs, management and control of deer and elk populations, public support for wildlife agencies and their ability to manage wildlife resources, the preservation of cultural and family traditions, and the economic viability of rural communities that are dependent on hunting revenues. Findings also suggested that nonresident hunters are more likely than residents to stop hunting deer/elk in the state as CWD conditions worsen. Declining numbers of nonresidents could significantly reduce agency revenue from license sales because they often pay much higher fees for hunting licenses. Taken together, these consequences of a decline in hunting participation due to CWD suggest the need for agencies and other stakeholders to engage in long-term and proactive management planning efforts for addressing the disease.

Although most of the CWD conditions manipulated in this study (i.e., high CWD prevalence, human health risks) are extremely unlikely, increased testing of harvested deer and elk (i.e., postmortem samples), advancements in lymphoid and tonsillar biopsy techniques for testing live animals (i.e., antemortem sampling), and in-vitro laboratory experiments of CWD in human cells may provide a more realistic assessment of current and future CWD prevalence levels and possible risks to human health associated with the disease (Raymond et al., 2000; Sigurdson et al., 1999; Wild, Spraker, Sigurdson, O'Rourke, & Miller, 2002; Wolfe et al., 2002).

Findings presented here also showed that hunters believed that irrespective of CWD prevalence levels and human health risks, CWD testing and allowing hunters to dramatically reduce deer and/or elk populations in affected areas to lower the potential for CWD spreading are acceptable actions for addressing the disease. Taking no action and allowing the disease to take its natural course are highly unacceptable. Results also showed considerable disagreement among hunters regarding the acceptability of using trained agency staff to reduce herds in affected zones. These findings imply that in all circumstances, hunters feel that agency effort is required to manage CWD. At low prevalence levels (e.g., 10% in some areas), hunters feel that testing or a combination of testing and lethal management using hunters would be acceptable. If CWD conditions ever become more severe (e.g., 50% prevalence, human death), a combination of testing and lethal management using trained agency staff and hunters would be acceptable. It remains a question of future research, however, to determine whether these actions

will provide long-term solutions for managing CWD and if they are logistically and politically feasible.

Given the long incubation period of CWD and its slow rate of natural expansion, these types of surveillance and eradication programs can be time consuming, controversial, expensive, and draw resources from other wildlife issues (Heberlein, 2004; Williams et al., 2002). These complications provide further rationale for wildlife agencies to carefully plan their long-term response to CWD, which should include input from various stakeholders with economic, recreational, governmental, and ecological interests in hunting and CWD (Decker et al., 2001).

Overall, this article represents the initial phase of the first empirical study to investigate the human dimensions of CWD across different states and hunting subgroups (e.g., residents, nonresidents). Future phases of this study will attempt to address some of the research needs identified here. Researchers are encouraged, however, to implement various theoretical and methodological techniques to further understand the human dimensions of CWD.

Notes

1. Further support for using prevalence and health risks as indicators of hunters' behavior in response to CWD was obtained from open-ended survey questions that asked hunters to list circumstances related to CWD that would cause them to give up deer/elk hunting either in the state or permanently. Across all hunters, the most dominant responses were related to CWD prevalence levels (89%) and potential human health risks or death as a result of CWD (77%).

2. Ancillary analyses showed no significant differences (after Bonferroni correction) among the eight states and between deer and elk hunters regarding responses to each hypothetical situation. Effect sizes were minimal ($V = .12$ to $.19$) (Vaske et al., 2002).

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