Supplementary materials for Journal of Wildlife Diseases DOI: 10.7589/JWD-D-20-000226: Mary M. Conner, Mary E. Wood, Anne Hubbs, Justin Binfet, A. Andrew Holland, Luke R. Meduna, Annette Roug, Jonathan P. Runge, Todd D. Nordeen, Margo J. Pybus, and Michael W. Miller. The Relationship Between Harvest Management and Chronic Wasting Disease Prevalence Trends in Western Mule Deer Herds.

SUPPLEMENTARY MATERIAL

The Relationship Between Harvest Management and Chronic Wasting Disease Prevalence Trends in Western Mule Deer Herds

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SUPPLEMENTARY MATERIALS AND METHODS

Because our analyses combined data from jurisdictions with different harvest strategies, CWD data, harvest and population data, and management goals, we followed the general approach laid out in Anderson et al. (1999) for analyzing empirical data related to natural resource controversies. This approach has been applied to large-scale meta-analyses (e.g., Irwin et al. 2020 and references therein). In particular, we employed recommendations for workshop participation, data inclusion, and analysis protocols (Anderson et al. 1999). Every step was transparent and documented. We analyzed data separately for each jurisdiction, and then convened a second workshop to evaluate results, determine what variables to carry forward, and identify additional variables to be included. We then joined the data from all jurisdictions and performed a meta-analysis.

Overall Modeling Goals and Approach

The specific goals of this project were to assemble and synthesize available, long-term data on herd and harvest management and CWD prevalence trends from cooperating western North American jurisdictions, and then to analyze these data to identify whether there were harvest practices showing evidence of association with reducing, stable, or increasing trends in CWD prevalence.

Five agencies participated in this CWD meta-analysis project: Alberta Environment and Parks, Colorado Parks and Wildlife, Nebraska Game and Parks, Utah Division of Wildlife Resources, and Wyoming Game and Fish Department. We refer to these respective states and province collectively as jurisdictions throughout. Representatives from each agency attended the series of workshops, supplied relevant data, and reviewed analysis results.

Data and Areas Included in Analyses

Our analyses focused on mule deer because the most comprehensive data were available for this species. Insufficient data for females and yearling males for most units precluded inclusion of those demographic groups. Consequently, we limited analyses to data from adult male mule deer harvested by hunters. We summarized and compared data by spatially defined hunting management "units" as defined by respective jurisdictions (unit hereafter). Adult (≥2 yr old) male deer were well-represented in data from all five jurisdictions. Apparent CWD prevalence in this demographic group is readily measured, relatively high, shows measurable changes and trends through time, and correlates to underlying epidemic dynamics (Miller and Conner 2005; Grear et al. 2006; Miller et al. 2020; Miller and Wolfe 2021). The timing of CWD detection and availability of surveillance data during 2002−2017 determined the range and number of years covered by our analyses (Table 1). Harvest data 1, 2, or 3 yr prior (1999−2016) were used to populate "lagged" variables in logistic regression analyses, as described below.

Following the recommendation that management strategies should be evaluated for ≥10 yr (WAFWA 2017), we limited analyses to units with ≥10 yr of prevalence data. We further assumed that a sampling effort yielding a sum of ≥100 samples over multiple 3 yr periods during 2002−2017 was necessary. Thirty-six units from the five jurisdictions met these criteria (Table 1, S1; Fig. 1). The 36 units ranged in size from 455 to 20,221 km^2, distributed across a broad geographical region in which climate, topography, vegetation, and elevation varied widely, as did population size, the amount of harvest, hunting season timing, and the likely duration of CWD occurrence (Table S1; Fig. 1, 2, S1).

Annual data used included the number of adult male deer harvested, number of hunters, estimated population size and adult sex ratios in each unit (Table S2). Data on date harvested, date submitted for testing, and laboratory result (positive or not detected) were assembled from individual harvested adult male mule deer (*n*=43,918; Table S2). Given the retrospective nature of our analyses, we acknowledge some variation in data collection methods among participating jurisdictions (Table S2). All estimates of apparent CWD prevalence were annual and based on the harvest year, which was a portion (August–January) of a biological year defined as 15 June–14 June (Fig. S1).

Origins of Harvest and Timing Variables

We generated a list of exploratory variables at the first workshop (Table S3). Some variables were chosen based on previous research. For example, theoretical modeling (e.g., Wild et al. 2011; Potapov et al. 2016) and empirical data (e.g., Wolfe et al. 2018, Miller et al. 2020) suggested selective and nonselective removals might affect prevalence, leading us to hypothesize that the amount of harvest might relate to prevalence. Because the precise nature of suggested relationships between harvest and prevalence have not been fully evaluated, we also evaluated additional variables with potential relationship to prevalence trends. Unit- and year-specific data included harvest variables, such as the number of male deer harvested and the number of hunters. We also derived variables that were a combination of harvest variables (e.g., change in harvest) or a combination of a harvest variable and population estimate (e.g., "hunter effort"; Table S3). In general, these derivative variables represented harvest or hunter/license numbers relative to herd size. Because of the large variation in the area of the units and size of mule deer herds (Table S1), we included relative harvest variables to explore whether harvest and hunting pressure per animal may be more relevant than absolute measures. For example, the proportion of total males that were harvested rather than the absolute number harvested (which varies widely with population size and demography) may be more relevant (Potapov et al. 2016). Conversely, the absolute number may be more meaningful. For example, a two-fold proportional increase in harvest in a herd where harvest increased from 250 to 500 (+250) does not seem equivalent to an increase from 25 to 50 − also two-fold, but only +25 − in a herd of equal size. Consequently, we considered absolute and relative measures of harvest; see Supplemental Material for calculation of relative harvest variables.

In addition to variables describing the amount of harvest (collectively termed "harvest variables" hereafter), we included three variables that represented the timing of harvest. Conner et al. (2000) reported higher CWD prevalence in male deer harvested in hunts timed closer to the breeding season, leading us to hypothesize that prevalence trends could be related to the timing of harvest. We used CWD sample submission date to estimate timing of harvest. We initially evaluated the start day and median day of harvest. We defined start of harvest as the day (Julian day) when 1% of all samples were harvested, median day as the day when 50% of all samples were harvested, and length of season as the number of days between the start of harvest and the day the vast majority (80% for within jurisdiction and 90% in meta-analyses) of all samples were harvested.

Not all jurisdictions had the data required to generate each harvest variable, so the number of variables and models varied. For example, Nebraska and Alberta did not have male:female ("bucks:100 does") ratio data for many years and units, so the number of males post-harvest could not be estimated. For these jurisdictions, hunter effort was calculated using the total population size rather than the male subpopulation size and the proportional harvest variables including the proportion of adult males harvested (*propbharv*; Table S3) were not calculated.

We ran each harvest variable lagged by 1, 2, and−3 yr; that is, we input harvest variables from the previous year (e.g., 1 yr prior was a 1 yr lag), 2 years prior, and 3 years prior as independent variables, but not in the same model. To control for differences in CWD prevalence that may be density dependent, we also included estimates of population density in top models (defined below). Density was calculated as estimated population size divided by the spatial area (km^2) of the unit (refer to Table S2 for methods). Estimates of population size came from integrated population models or simpler population reconstruction style models (Table S2); all density estimates were post-harvest except for Alberta units, where estimates were from immediately pre-harvest.

Analysis Approach

Because the CWD test result (positive or not) was a binary response variable, we used logistic regression models for these analyses (Agresti 2007; Hosmer et al. 2013). Note that CWD prevalence refers to the proportion of samples that were positive, which is the average of the predicted probabilities, also called sample or empirical logit (Agresti 2007). We ran all analyses in R using the glm or glmer functions (R Core Team 2018). For all model selection, we used an information–theoretic approach (Burnham and Anderson 2002) to rank candidate models and select an appropriate model. We used Akaike's Information Criterion (AIC; Akaike 1973) to rank models and ΔAIC and model weights to evaluate and select "top" models (Burnham and Anderson 2002). We regarded models with $\Delta AIC \leq 2$ as competitive with the top model ($\Delta AIC=0$).

Within Jurisdiction Analyses

We began by performing logistic regression analyses and model selection for the units within each jurisdiction. Analyzing data from each jurisdiction helped us identify unique features and limitations of respective data sets that needed to be considered in a combined meta-analysis. Moreover, the results helped inform the variables used in the meta-analysis. To reduce the number of models, we used a sequential process for model development (Nichols et al. 1997) with two sets of models. The first set of models (base models) had only spatial (*unit*), initial prevalence, and temporal (*year*) effects. Initial ("starting") prevalence was estimated for each unit as the weighted mean prevalence over the first 3 yr of the study period (e.g., total number of positive samples from the first 3 yr/total number of samples from the first 3 yr), and initial prevalence as a categorical variable with units modeled as being low prevalence ($prev \leq 02$), medium prevalence ($0.2<prev<0.10$), or high prevalence (prev ≥0.10). We also constructed a model with units categorized as well as low-medium (prev < 0.10) or high prevalence (prev ≥0.10). Because we used CWD data only from hunter-harvested adult male mule deer, we had a limited number of base models. The suite of base models included no variation (null) and single, additive, and interactive combinations of unit or initial prevalence and annual temporal variation (year) in CWD prevalence. We modeled year as a categorical effect, a constant, a linear trend, a quadratic trend, and as a log-linear ("pseudo threshold") trend. The top base model for all jurisdictions except Utah was *logit(CWD prev)=unit+year+unit×year*, with year modeled as a linear trend. This model was 1.5 ΔAIC units from Utah's top base model [*logit(CWD prev)=unit+year*)] and so effectively tied. The *logit(CWD prev)=unit+year+unit×year* base model yielded patterns of increasing CWD prevalence that varied across units for all jurisdictions (Fig. S3).

We then used the (*logit(CWD prev)=unit+year+unit×year*) base model to construct models that included harvest-related variables (e.g., *logit(CWD prev)=unit+year+unit×year+*number of male deer harvested). The base model became the new null model as it did not contain explanatory harvest variables. Before beginning model construction with harvest variables, we checked for correlations among the harvest variables, density, and within each variable for the different lags. There were no strong correlations (r>0.6) among most harvest variables within jurisdictions, except for number of males harvested and number of hunters (r>0.7). In addition, the number of males harvested and number of hunters were typically strongly correlated among the lags (r>0.8 for 78% of lagged variables). We did not include any correlated variables in the same model. For all harvest variables available for each jurisdiction, we constructed models wherein the harvest variable, modeled as a linear trend, was added to the base model (e.g., *logit(CWD prev)=unit+year+unit×year+*harvest variable).

In addition, we constructed a model where the harvest variable replaced year (e.g., *logit(CWD prev)=unit×huntereffort*) and, for the top model(s), we included population density to explore potential interaction between density and harvest variables as well as to help standardize for size differences among units.

SUPPLEMENTARY RESULTS

The initial baseline model produced increasing trends in CWD prevalence over time in all jurisdictions. The rate of increase varied among and within jurisdictions, with particularly steep increases in some Alberta, Nebraska, and Wyoming units (Fig. S3). These observations illuminated the pattern of the *unit+year+unit×year* baseline model for within-jurisdiction analyses; that is, initial CWD prevalence varied by unit, as did trends in CWD prevalence over time.

Within-Jurisdiction Analyses

Models including harvest variables also yielded generally increasing CWD prevalence trends for all jurisdictions. As with baseline modeling, the initial prevalence and rate of increase varied widely among units.

Various combinations of harvest and its timing showed the closest relationships to CWD prevalence patterns observed in individual jurisdiction data (Table S4). The number of males harvested occurred in some representation – number, proportion, or change – among one or more of the competitive models (within 2 ΔAICc units of the top model) for each jurisdiction. Representations of harvest timing also were included among the competitive models for Alberta, Colorado, and Wyoming. The baseline model (no harvest variables) was competitive only for the Utah data set. Despite those commonalities, the relationship between harvest variables and CWD prevalence in the top models was not consistent across jurisdictions (Table S5).

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Table S1. Thirty-six western Canadian or United States mule deer (*Odocoileus hemionus*) herds or harvest management entities (called "*units*" in the main text) included in meta-analysis of harvest (via hunting) management and chronic wasting disease (CWD) prevalence trends listed by jurisdiction. This summary includes the unit number or name, their approximate spatial size, estimated deer abundance (before hunting), chronic wasting disease history and prevalence at the beginning and end of the 2002–2017 study period, and the range of harvest and numbers of hunters (or licenses sold) and observed sex ratios in the relevant hunting seasons from 1999–2016. AB = Alberta, Canada; CO = Colorado, USA; NE = Nebraska, USA; UT = Utah, USA; WY = Wyoming, USA.

					CWD Prevalence		Adult Male Harvest		Hunters		Bucks:100 Does	
Jurisdiction	**Unit**	**Area (km^2)**	**Abundance (range)**	**Year CWD First Detected**	**Start (3-yr)**	**End (3-yr)**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**
AB	118	1,964	1544-5055	2013	0.0%	5.0%	44-261	159	73-419	261	na[a]	na
AB	148	2,880	523-3652	2013	0.0%	7.8%	26-181	93	112-322	194	na	na
AB	150	1,828	457-959	2005	0.4%	13.6%	17-98	52	30-358	145	na	na
AB	151	2,981	1694-3182	2005	0.3%	10.7%	64-160	114	111-353	237	na	na
AB	162	4,761	1111-2770	2011	0.0%	8.7%	77-152	110	98-281	188	na	na
AB	163	3,396	1499-2487	2007	2.4%	8.4%	71-141	110	103-244	192	na	na
AB	200	2,726	1587-6589	2009	0.0%	11.4%	154-338	220	242-1378	626	na	na
AB	202	2,203	1208-4710	2009	0.0%	11.9%	71-226	172	164-490	355	na	na
AB	234	2,584	911-3822	2006	0.4%	12.7%	0-189	107	78-902	429	na	na
AB	236	3,053	899-2395	2007	0.5%	20.6%	103-163	142	261-742	419	na	na
AB	728	455	1621-3619	2008	0.7%	5.1%	73-222	142	462-714	598	na	na
CO	2	7,293	30084-45501	2002	0.5%	8.6%	1905-4330	2725	4143-9995	6279	20-45	29
CO	4	4,635	8304-16600	<1990	11.4%	4.3%	502-1116	741	2376-5028	3921	26-42	33
CO	7	10,670	33958-74241	2002	1.4%	15.4%	1498-5310	2991	3549-14777	7745	19-38	27
CO	8	3,765	12977-22779	2003	0.6%	11.1%	496-1676	1037	2138-6092	4033	26-44	32
CO	9	6,183	13665-19848	2002	0.9%	2.4%	578-1747	1149	3459-7225	6600	32-54	42
CO	10	3,123	7001-8877	<1990	11.1%	12.7%	317-589	447	995-2328	1733	31-51	40
CO	12	3,820	1617-23253	2002	0.3%	9.1%	1008-1886	1324	2515-4748	3503	20-29	24
NE	FR	15,574	15452-19546	2007	0.0%	1.1%	1166-1667	1393	1783-3314	2601	10-42	27
NE	PR	8,629	9497-12828	2001	0.7%	11.3%	648-1021	862	1716-2617	2059	13-26	21
NE	PLN	16,538	8715-12901	2002	1.6%	4.9%	591-877	764	1344-2057	1653	15-26	20

NE	PLT	13,147	9361-13609	2010	0.0%	0.3%	699-968	828	1103-2182	1702	19-53	31
NE	SH	20,221	10469-14619	2004	0.4%	2.2%	764-1498	1096	1438-3012	2104	17-84	45
NE	UP	11,439	5617-8880	2000	1.5%	2.1%	380-706	539	1105-1621	1278	19-40	25
UT	9.1	10,619	21112-26421	2002	0.3%	1.0%	1266-2493	1694	3761-7128	5149	21-27	23
UT	13	7,110	8133-12662	2003	4.1%	9.1%	429-808	581	1229-2608	1781	13-28	20
UT	16	12,950	20634-53902	2003	0.6%	1.5%	4443-2599	3343	11849-16631	13820	12-21	16
WY	427	8,679	16895-26978	2000	0.5%	7.1%	730-1962	1332	1985-3670	2848	19-36	24
WY	751	8,239	18843-33874	2004	0.0%	0.0%	1128-2500	1951	3767-7282	5827	14-51	28
WY	740	14,206	21197-35064	2000	0.9%	17.6%	830-2484	1558	1626-5497	3267	25-60	39
WY	537	12,429	16606-29556	1992	17.4%	21.8%	836-1402	1069	1879-2558	2151	27-47	37
WY	541	6,690	11602-21708	2002	1.7%	5.8%	379-1807	999	869-4462	2844	20-49	31
WY	539	6,421	5878-14147	2002	4.6%	8.6%	146-666	453	1194-2342	1806	22-47	30
WY	756	3,165	4253-13070	1999	25.9%	41.1%	237-636	392	595-1639	999	27-44	36
WY	208	7,589	9985-15405	2003	0.0%	6.9%	762-1304	1040	1960-2966	2443	20-49	34
WY	322	3,577	9560-12716	2004	0.0%	12.1%	634-1012	831	1362-2214	1696	30-44	36

[a] na=not available

Table S2. Brief descriptions of methods used to acquire population-level (called "*units*" in the main text) and individual animal data used in a meta-analysis of harvest (via hunting) management and chronic wasting disease prevalence trends for adult male mule deer (*Odocoileus hemionus*) harvested from western Canadian (Alberta) or United States (Colorado, Nebraska, Utah, Wyoming) jurisdictions, 1999–2017.

	Jurisdiction				
Data	Alberta	Colorado	Nebraska	Utah	Wyoming
Population-level data					
Number of male deer harvested	survey sample of licensed hunters	survey sample of licensed hunters	mandatory check, visual inspection & hunter self-report	survey sample of licensed hunters	survey sample of licensed hunters
Number of hunters (male deer)	licenses sold, surveys, and check stations	licenses sold	bucks harvested/success rate for unit tag (includes tags valid statewide)	survey sample of licensed hunters	hunters reporting they hunted on license within harvest survey
Population size	spreadsheet model & periodic aerial survey	integrated population-based spreadsheet model	estimated via SAK-based spreadsheet model	integrated population-based spreadsheet model	integrated population-based spreadsheet model
Male:female sex ratio	na[a]	helicopter inventory	na	postseason ground classification	postseason aerial/ground classification surveys
Individual sample data					
Species	visual inspection	visual inspection	visual inspection	visual inspection	visual inspection
Sex	visual inspection	visual inspection	visual inspection	visual inspection	visual inspection
Age	incisor replacement	incisor replacement	visual inspection of tooth wear and replacement	incisor replacement	fawn: visual inspection; yearling: 3rd premolar &/or antlers; adult (2+): tooth &/or antler inspection, cementum annuli in recent years

Harvest (collection) date	as reported by hunter	as reported by hunter	as reported by hunter	as reported by hunter	as reported by hunter
Source/method of take	recorded at submission	recorded at submission	recorded at submission	recorded at submission	recorded at submission
Laboratory result	ELISA on RLN tissue[b]	ELISA on RLN tissue	ELISA on RLN tissue	ELISA on RLN tissue	ELISA on RLN tissue

[a] na=not available

[b] Enzyme-linked immunosorbent assay (e.g., Hibler et al. 2003) performed on retropharyngeal lymph node tissue.

Table S3. Variables considered and used for individual jurisdictions in analysis of harvest (via hunting) management and chronic wasting disease prevalence trends during 2002–2017 for adult male ("buck") mule deer (*Odocoileus hemionus*) harvested from western Canadian or United States jurisdictions. All variables were lagged 1-3 yr (*1*, *2* and *3* at the end of the variable name indicates the number of years the variable was lagged).

Variable	Description	Variable acronym
Variables used in analysis of individual area		
Number of adult males harvested	Estimated from harvest surveys	*bharvno*
Change in harvest	Number of bucks harvested this year (*t*) - number of bucks harvested previous year (*t*-1)	*chngharv*
Active number of licenses[a]	Estimated from harvest surveys	*hunter*
Median day of harvest	Julian day where 50% of all samples were submitted each year	*day50*
Proportion of adult males harvested[b]	Number of bucks harvested / estimated population size just prior to hunting seasons	*propbharv*
proportion of adult males harvested[b]	Number of bucks harvested / number of bucks in population just prior to hunting seasons	*propbharv*
Hunter effort	Number licenses sold / estimated population size just prior to hunting seasons	*hunteff*
Start day of harvest	Julian day where 1% of all samples were submitted each year	*startday*
Median day of harvest	Julian day where 50% of all samples were submitted each year	*day50*
Length of harvest	Difference (in days) between Julian day where 80% of all samples were submitted and Julian day where 1% of all samples were submitted each year	*len80*
Density	Population size / area of hunt area for each herd	*density*
Variables considered initially but not used		
Number of does harvested	Estimated from harvest surveys	
Number of licenses sold per adult male population size	Number of licenses sold / number of bucks in population just prior to hunting season	
Population size	Estimates come from a variety of models, from POPAN style to IPMs; post-harvest in all but Nebraska	
Adult male population size	Calculated from population size and buck:doe and fawn:doe ratios	
buck:doe ratio	Estimated from field surveys, usually post-harvest	
fawn:doe ratio	Estimated from field surveys, usually post-harvest	
proportion change in harvest	Change in harvest / number of bucks in population just prior to hunting season	

[a] This was estimated from number of licenses sold and was also called number of hunters afield.

[b] Every jurisdiction except Alberta estimated post-harvest population size. To estimate pre-hunt population size for these jurisdictions, we added the total number of bucks, does, and fawns harvested to the post-hunt population size.

Table S4. Model selection results showing top three models from analysis of harvest (via hunting) management and chronic wasting disease (CWD) prevalence trends during 2002–2017 for adult male mule deer (*Odocoileus hemionus*) harvested from western Canadian (Alberta), or United States herds (Colorado, Nebraska, Utah, or Wyoming). All variables were lagged 1–3 yr (1, 2 or 3 at the end of the variable name indicates the number of years the variable was lagged). We regarded models with ΔAIC≤2 as competitive with the top model (ΔAIC=0.00).

Jurisdiction	Model	K	AIC	ΔAIC	Model weight
Alberta	*unitxyear+len80.1*	23	1956.65	0.00	0.65
	unit×year+len80.1+bharvno2	24	1958.41	1.76	0.27
	unit×year+startday1+bharvno2	24	1960.83	4.18	0.08
Colorado	*unitxyear+bharvno1*	15	5754.55	0.00	0.17
	unitxyear+pchngharv1	15	5755.69	1.14	0.10
	unitxyear+bharvno1+medday2	16	5756.09	1.54	0.08
Nebraska	*unit×year+chngharv2*	13	1358.51	0.00	0.17
	unit×year+den1	13	1359.34	0.82	0.12
	unit×year+den1+chngharv2	14	1359.86	1.34	0.09
Utah	*unit×year+chngharv3*	7	406.14	0.00	0.12
	unit×year+propbharv3	7	407.05	0.91	0.07
	unit×year	6	407.6	1.47	0.06
Wyoming	*UnitxYear+bharvno1+medday1*	20	3040.47	0.000	0.86
	UnitxYear+bharvno1plus2+startday1	20	3046.63	6.160	0.04
	UnitxYear+bharvno1+startday1	20	3046.97	6.500	0.03

Table S5. Parameter estimates for harvest variables in the two top models from analysis of harvest (via hunting) management and chronic wasting disease (CWD) prevalence trends during 2002–2017 for adult male mule deer (*Odocoileus hemionus*) harvested from western Canadian (Alberta), or United States herds (Colorado, Nebraska, Utah, or Wyoming). All variables were lagged 1–3 yr (1, 2, or 3 at the end of the variable name indicates the number of years the variable was lagged). We regarded models with ΔAIC≤2 as competitive with the top model (ΔAIC=0.00; Table S4).

Jurisdictioon	Top Models	Parameter	Estimate	Standard Error	*z* value	Pr(>|*z*|)
Alberta	*unit×year+len80.1*	*len80.11*	0.035	0.007	4.791	<0.001
	unit×year+len80.1+bharvno2	*bharvno2*	1.064	2.164	0.492	0.623
Colorado	*unit×year+bharvno1*	*bharvno1*	−0.233	0.092	−2.536	0.011
	unit×year+pchngharv1	*pchngharv1*	−1.477	0.629	−2.349	0.019
Nebraska	*unit×year+chngharv2*	*chngharv2*	−0.002	0.001	−2.300	0.021
	unit×year+den1	*den1*	−1.103	0.540	−2.043	0.041
Utah	*unit×year+chngharv3*	*chngharv3*	0.001	0.000	1.767	0.077
	unit×year+propbharv3	*propbharv3*	3.796	2.385	1.592	0.112
Wyoming[a]	*unit×year+bharvno1+medday1*	*bharvno1*	1.227	0.333	3.689	<0.001
		medday1	0.044	0.014	3.172	0.002

[a] Only one model was competitve.

Table S6. Complete model selection results for meta-analysis of harvest (via hunting) management and chronic wasting disease (CWD) prevalence trends during 2002–2017 for adult male mule deer (*Odocoileus hemionus*) harvested from the 32 western Canadian or United States herds ("*Unit*") with low initial CWD prevalence (≤0.05). All variables were lagged 1 Year and the cumulative total from lags of 1 plus 2 Year (i.e., *1* or *1plus2* at the end of the variable name indicates the number of years the variable was lagged). We used random effects (*RE*) to model the intercept (*UnitRE*) and slope (*YearRE*). See Table S3 for variable descriptions.

Model	*K*	AIC	ΔAIC	Model weight
UnitRE+YearRE+bharvno1+pkrutto50.1	6	7,837.2	0.00	0.29
UnitRE+YearRE+bharvno1plus2+pkrutto50.1	6	7,838.5	1.33	0.15
UnitRE+YearRE+hunter1+pkrutto50.1	6	7,838.6	1.39	0.15
UnitRE+YearRE+hunter1plus2+pkrutto50.1	6	7,839.2	1.99	0.11
UnitRE+YearRE+bharvno1	5	7839.44	2.27	0.09
UnitRE+YearRE+hunter1	5	7,840.3	3.09	0.06
UnitRE+YearRE+bharvno1plus2	5	7840.86	3.69	0.05
UnitRE+YearRE+hunter1plus2	5	7,841.0	3.81	0.04
UnitRE+YearRE+huntereff1plus2	5	7,843.2	6.03	0.01
UnitRE+YearRE	4	7,843.9	6.68	0.01
UnitRE+YearRE+chngbharv1	5	7843.90	6.73	0.01
UnitRE+YearRE+huntereff1	5	7,845.0	7.78	0.01
UnitRE+YearRE+propbharv1plus2	5	7845.35	8.18	0.00
UnitRE+YearRE+pkrutto50.1	5	7,845.4	8.27	0.00
UnitRE+YearRE+medday1	5	7,845.6	8.4	0.00
UnitRE+YearRE+pkrutto90.1	5	7,845.6	8.43	0.00
UnitRE+YearRE+propbharv1	5	7845.79	8.62	0.00

Table S7. Parameter estimates from the two top models in meta-analysis of harvest management and chronic wasting disease (CWD) prevalence trends during 2002–2017 for adult male mule deer (*Odocoileus hemionus*) harvested from the 32 western Canadian or United States herds ("*Unit*") with low initial CWD prevalence (≤0.05). The timing variable (*pkrutto50.1*) was lagged 1 yr. Harvest variables were lagged 1 yr or reflected the cumulative total from lags of 1 plus 2 yr (i.e., *1* or *1plus2* at the end of the variable name indicates the number of years the variable was lagged). We used random effects (*RE*) to model the intercept (*UnitRE*) and slope (*YearRE*), but here we show their fixed effect estimates. See Table S3 for variable descriptions.

Model weight	Parameter	Estimate	Standard Error	*z* value	Pr(>|*z*|)
0.29	*Unit*	−6.351	0.370	−17.149	<0.001
	Year	0.272	0.028	9.679	<0.001
	bharvno1	−0.218	0.082	−2.664	0.008
	pkrutto50.1	1.744	0.879	1.984	0.047
0.15	*Unit*	−6.353	0.369	−17.235	<0.001
	Year	0.271	0.028	9.649	<0.001
	bharvno1to2	−0.106	0.045	−2.382	0.017
	pkrutto50.1	1.772	0.868	2.042	0.041

Table S8. Complete model selection results for meta-analysis of harvest management and chronic wasting disease (CWD) prevalence trends during 2002–2017 for adult male mule deer (*Odocoileus hemionus*) harvested from two Colorado, USA, and two Wyoming, USA, management units ("*Unit*") with high initial CWD prevalence (>0.05). All timing variables were lagged 1 yr. Harvest variables were lagged 1 yr or reflected the cumulative total from lags of 1 plus 2 yr (i.e., *1* or *1plus2* at the end of the variable name indicates the number of years the variable was lagged). See Table S3 for variable descriptions.

Model	*K*	AIC	ΔAIC	Model weight
*Unit*Year + Unit*hunter1to2*	12	4,791.07	0.00	0.36
*Unit*Year + Unit*hunter1to2 + pkrutot50.1*	13	4,791.10	0.03	0.36
*Unit*Year + Unit*hunter1to2 + Unit* pkrutot50.1*	16	4,792.92	1.85	0.14
*Unit*Year + Unit*hunter1*	12	4,793.30	2.23	0.12
*Unit*Year + Unit*bharvno1to2*	12	4,798.49	7.42	0.01
*UnitxYear+Unit*bharvno1*	12	4,799.68	8.61	0.00
*Unit*Year + Unit*huntereff1to2*	12	4,803.82	12.75	0.00
*Unit*Year + Unit*huntereff1*	12	4,803.89	12.82	0.00
*Unit*Year + Unit*propbharv1to2*	12	4,806.00	14.93	0.00
*Unit*Year+Unit*medday1*	12	4,808.0	16.91	0.00
*Unit*Year + Unit*propbharv1*	12	4,808.07	17.00	0.00
*Unit*Year*	8	4,809.04	17.97	0.00
*Unit*Year +Unit* Unit*pkrutto90.1*	12	4,810.40	19.37	0.00
*Unit*Year + Unit*chngbharv1*	12	4,813.00	21.93	0.00

Table S9. Parameter estimates from the two top models (parameter estimates were virtually identical in the 2 top models for all but the timing variable, which was not in the nominally top model) in meta-analysis of harvest management and chronic wasting disease (CWD) prevalence trends during 2002–2017 for adult male mule deer (*Odocoileus hemionus*) harvested from two Colorado, USA, and two Wyoming, USA, herds ("*Unit*") with high initial CWD prevalence (≥0.11). The top models included individual unit interactions, and consequently parameter estimates are denoted by herd (Colorado: *CO04* and *CO10;* Wyoming: *WY537* and *WY756*). The timing variable (*pkrutto50.1*) was lagged 1 yr. The harvest variable (*hunter1plus2*) reflected the cumulative total from lags of 1 plus 2 yr. See Table S3 for variable descriptions.

Parameter	Estimate	Standard Error	z value	Pr(>|z|)
Intercept (*Unit CO10*)	-1.961	0.340	-5.771	<0.001
CO4 (additive intercept for *CO4*)	-0.867	0.568	-1.526	0.127
WY537 (additive intercept for *WY537*)	-1.788	0.747	-2.394	0.017
WY756 (additive intercept for *WY756*)	3.249	1.044	3.111	0.002
year (slope for *CO10*)	0.012	0.015	0.786	0.432
year (additive slope for *CO4*)	-0.108	0.022	-5.003	<0.001
year (additive slope for *WY537*)	-0.011	0.021	-0.509	0.611
year (additive slope for *WY756*)	-0.041	0.046	-0.896	0.370
hunter1plus2 (slope for *CO10*)	-0.014	0.082	-0.171	0.864
hunter1plus2 (additive slope for *CO4*)	0.157	0.108	1.449	0.147
hunter1plus2 (additive slope for *WY537*)	0.651	0.171	3.803	0.000
hunter1plus2 (additive slope for *WY756*)	-0.634	0.329	-1.926	0.054
pkrutto50.1 (additive slope for all units)	-1.385	0.991	-1.910	0.162

Jurisdiction	Unit	A	S1	S2	S3	S4	O1	O2	O3	O4	N1	N2	N3	N4	D1	D2	D3	D4	J	F
			September				October				November				December					
CO	2		A	a	aM	am			R2	R3	r3	R4								
	4		A	a	aM	am			R2	R3	r3	R4								
	7		A	a	aM	am			R2	R3	r3	R4								
	8		A	a	aM	am			R2	R3	r3	R4								
	9		A	a	aM	am			R2	R3	r3	R4								
	10		A	a	aM	am			R2	R3	r3	R4	RL*	rL						
	12		A	a	aM	am			R2	R3	r3	R4								
AB	118		A	a	a	a	a	a	a	a	Ri	Rii	Riii	Riv						
	148		A	a	a	a	a	a	a	a	Ri	Rii	Riii	Riv						
	150		A	a	a	a	a	a	a	a	Ri	Rii	Riii	Riv						
	151		A	a	a	a	a	a	a	a	Ri	Rii	Riii	Riv						
	162		A	a	a	a	a	a	a	a	aR	r	r	r						
	163		A	a	a	a	a	a	a	a	aR	r	r	r						
	200		A	a	a	a	a	a	a	a	aR	r	r	r						
	202		A	a	a	a	a	a	a	a	aR	r	r	r						
	234		A	a	a	a	a	a	a	a	aR	r	r	r						
	236		A	a	a	a	a	a	a	a	aR	r	r	r						
	728		A	a	a	a	a	a	a	a				A	R1,2,3,4					
WY	427		A	a	a	a	R	r	r											
	751		A	a	a	a					R	r	r	r						
	740		A	a	a	a	R	r												
	537		A	a	a	a			R	r										
	541		A	a	a	a	R	r												
	539		A	a	a	a	R	r												
	756		A	a	a	a			R	r										
	208		A	a	a	a			R	r										
	322		A	a	a	a			R	r										
UT	9	A	a	a		M		R1	R2											
	13	A	a	a		M		R1	R2											
	16	A	a	a		M		R1	R2											
NE	FR		A	a	a	a	aR	ar	a	a	a	aR	ar	a	aM	am	am	am	R	
	PR		A	a	a	a	aR	ar	a	a	a	aR	ar	a	aM	am	am	am	R	
	PLN		A	a	a	a	aR	ar	a	a	a	aR	ar	a	aM	am	am	am	R	
	PLT		A	a	a	a	aR	ar	a	a	a	aR	ar	a	aM	am	am	am	R	
	SH		A	a	a	a	aR	ar	a	a	a	aR	ar	a	aM	am	am	am	R	
	UP		A	a	a	a	aR	ar	a	a	a	aR	ar	a	aM	am	am	am	R	

Figure S1. Hunting seasons and relative season timing during 1999–2017 in 36 western Canadian or United States mule deer (*Odocoileus hemionus*) management units (called "*units*" in the main text) included in meta-analysis of harvest (via hunting) management and chronic wasting disease prevalence trends, listed by jurisdiction. This summary includes the unit number or name referenced in Table S1 and elsewhere. Abbreviations: R=rifle season opening; A=archery season opening; M=muzzleloader season opening. If season extends over multiple weeks, continuation shown in lower case; multiple seasons/openings designated as -1, -2, etc. (see CO for examples). *L=late rifle season (private land only) hunt; Ri-iv=multiweek rifle season (hunt 4 days with 3-day breaks), with the same hunters participating in each season. (AB=Alberta, Canada; CO=Colorado, USA; NE=Nebraska, USA; UT=Utah, USA; WY=Wyoming, USA.)

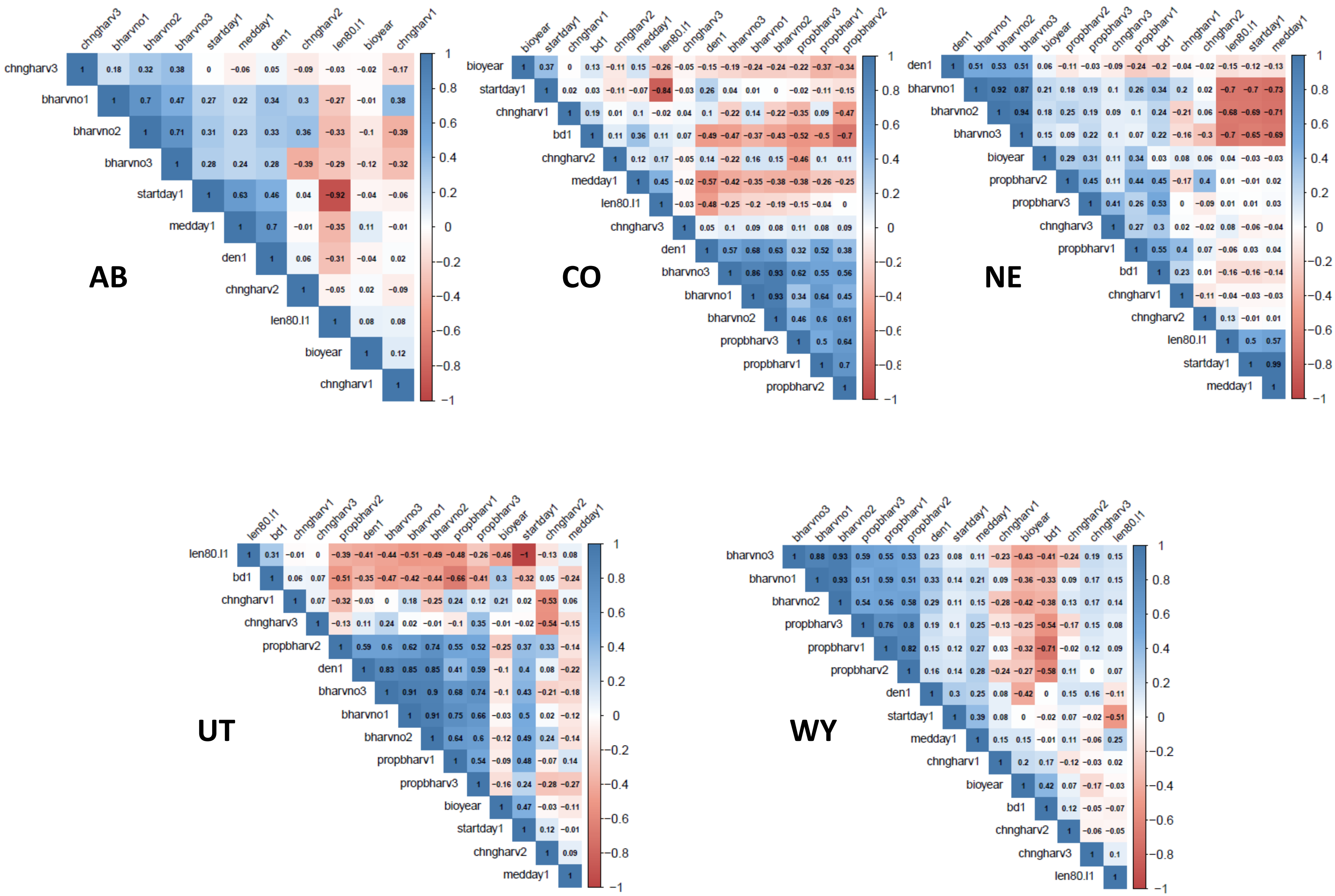

Figure S2. Correlations among harvest variables during 1999–2017 in 36 western Canadian or United States mule deer (*Odocoileus hemionus*) management units (called "*units*" in the main text) included in meta-analysis of harvest (via hunting) management and chronic wasting disease prevalence trends, listed by jurisdiction. See Table S3 for variable descriptions. (AB=Alberta, Canada; CO=Colorado, USA; NE=Nebraska, USA; UT=Utah, USA; WY=Wyoming, USA.)

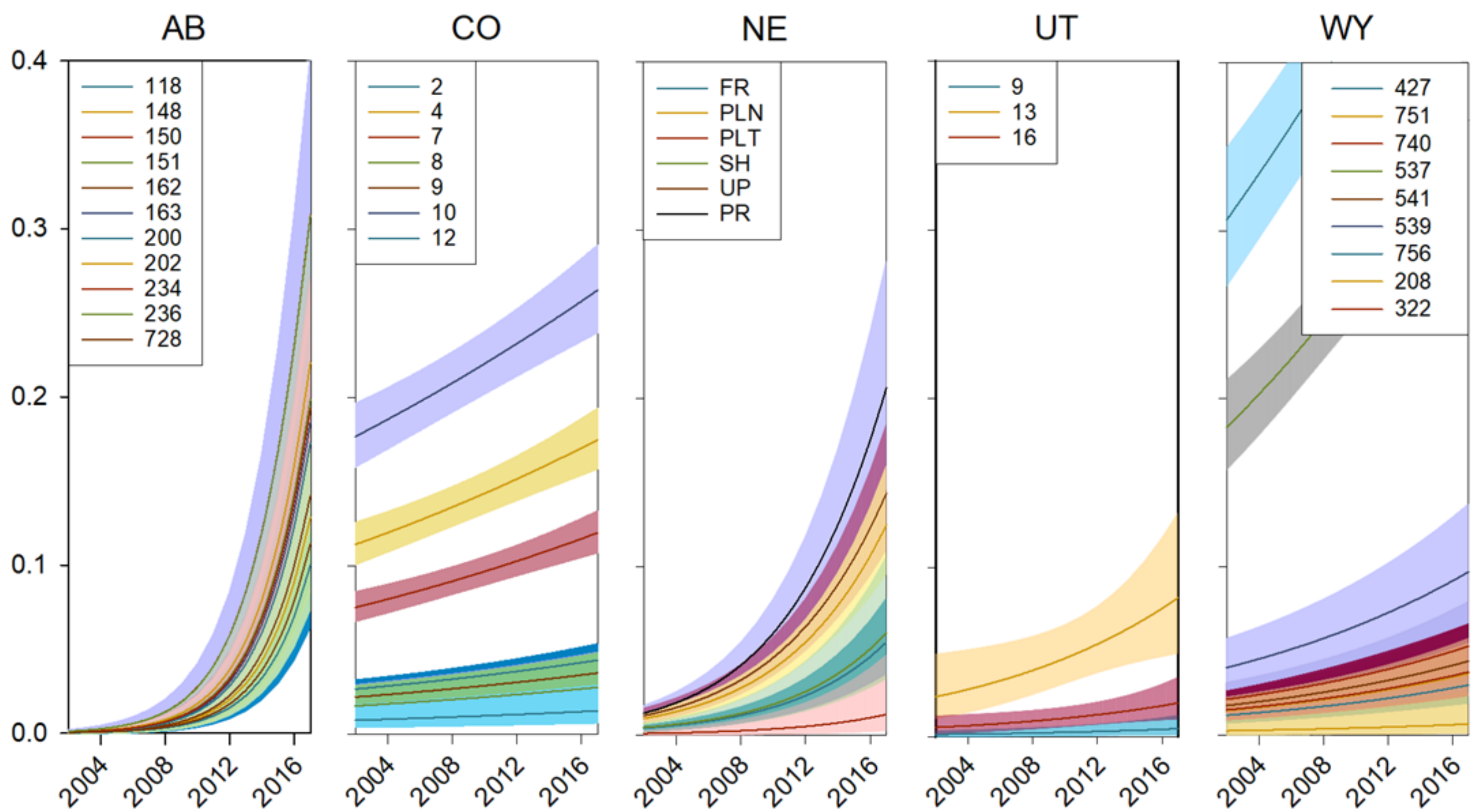

Figure S3. Modeled chronic wasting disease (CWD) prevalence trends during 2002–2017 for adult male mule deer (*Odocoileus hemionus*) harvested from western Canadian or United States herds ("*unit*"). Model-averaged prevalence estimated from harvested ≥2 yr old male deer reflected observed variation across the 36 mule deer management units (Table S1) included in our analyses. Graphs represent CWD prevalence from the base model *logit(CWD prev)=unit+year+unit×year* (i.e., before adding explanatory harvest or timing variables). (AB=Alberta, Canada; CO=Colorado, USA; NE=Nebraska, USA; UT=Utah, USA; WY=Wyoming, USA.)