Expanding the Surveillance Optimization Project for Chronic Wasting Disease Model to Western North America

Technical Report – Project Summary and Model Tutorial
Western Association of Fish and Wildlife Agencies

March 2026

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Executive Summary

The Surveillance Optimization Project for Chronic Wasting Disease (SOP4CWD) is a project led by a group of interdisciplinary researchers to support North American wildlife agencies surveilling for and managing chronic wasting disease (CWD) in free-ranging cervid populations. The original SOP4CWD surveillance model (Hazard Model, Schuler et al. 2025) provides agencies with a tool that helps them determine how to allocate limited surveillance resources by estimating the risk of CWD introduction for individual management units across a state or province based on the presence of human- and cervid-based risk factors. The original Hazard Model was developed for white-tailed deer in eastern habitats, limiting its applicability to western landscapes.

In 2023, through the Chronic Wasting Disease Management and Response Funding Opportunities, the U.S. Department of Agriculture Animal and Plant Health Inspection Service awarded Cornell University funding to expand the SOP4CWD Hazard Model in collaboration with the Western Association of Fish and Wildlife Agencies (WAFWA). Co-led by Krysten Schuler and the Cornell Wildlife Health Lab (CWHL), WAFWA's Interagency Health Specialist, Noelle Thompson, and Jon Cook at U.S. Geological Survey, the research team established a guidance committee to direct project development. Composed of wildlife disease specialists from the western US and Canada, the guidance committee developed the scope of the project, identified the unique landscapes to consider, and identified risk factors relevant to CWD introduction in western US and Canada. The team further invited 13 western CWD and cervid experts to estimate the likelihood that each risk factor may contribute to CWD introduction within a management unit.

Project personnel elicited risk estimates for two sample regions in the west: the Arid Southwest and Pacific Northwest. Experts in the Arid Southwest identified captive cervid facilities and feedgrounds (locations where mass feeding of cervids occurs annually by wildlife agencies) as the highest risk for CWD introduction, although these two factors had the largest variability in risk estimates among respondents. Experts in the Pacific Northwest were also highly variable in their estimates of risk produced by captive cervid facilities and feedgrounds, although these experts indicated that feedgrounds and dumping imported carcasses (or carcass waste) into the environment produced the highest introduction risks.

Outcomes of this project include: 1) a new version of the Hazard Model that fully addresses CWD risk factors associated with co-occurring cervid species in western landscapes, and 2) a user-friendly interface

in the SOP4CWD CWD Data Warehouse that allows wildlife managers to select and score risk factors based on conditions specific to their jurisdictions. Using the new model in the CWD Data Warehouse, outputs identify areas with disproportionately high risk of CWD introduction, which may improve managers' ability to plan where to sample for CWD and at what intensities across management units each year.

Background

The Surveillance Optimization Project for Chronic Wasting Disease (SOP4CWD; CWHL 2026) was founded in 2020 to support wildlife agencies across North America in responding to the challenges posed by chronic wasting disease (CWD). The overarching goal of SOP4CWD is to provide wildlife agencies in North America with technological and quantitative tools to improve CWD surveillance. One tool is the Hazard Model, a risk-based surveillance model designed to improve the efficiency of CWD sampling by assessing and identifying areas of elevated disease risk. Specifically, the Hazard Model estimates the likelihood of CWD introduction for each management unit based on the presence and number of risk factors, such as certain human activities (e.g., taxidermists and processors) and cervid population behaviors (deer density; Schuler et al. 2025). Where data are lacking, subject matter experts can be used to estimate the effects of risk factors (Schuler et al. 2016). The results of the Hazard Model can be used alone or in combination with SOP4CWD's Sample Allocation Model (SAM), an additional tool that allows managers to integrate hazard model outputs, prior surveillance efforts, and budget to determine sample allocation for each surveillance unit (Wang et al. 2025), to produce sampling quotas.

As of March 2026, 26 U.S. state and Canadian provincial wildlife agencies have formally partnered with SOP4CWD and can access the original Hazard Model and SAM within the CWD Data Warehouse. Nine of those agencies are members of the Western Association of Fish and Wildlife Agencies (WAFWA; WAFWA 2026). Access to the Data Warehouse and surveillance models supports these agencies in directing surveillance efforts across their jurisdictions. However, the original Hazard Model was developed for eastern and midwestern white-tailed deer populations, with risk factors identified by experts located in the eastern US. As a result, western-specific factors, such as seasonal migration and feedgrounds, were not included, limiting applicability to western ecosystems. Widespread interest in adapting the Hazard Model in western North America drove this interdisciplinary effort to expand the Hazard Model approach to include western risk factors and cervid species.

Western Expansion of the Hazard Model

<u>Overview</u>

Acknowledging that CWD introduction risks in eastern and midwestern jurisdictions do not represent the full suite of risk factors for all jurisdictions, SOP4CWD, in collaboration with N. Thompson from WAFWA, applied for and was awarded funding by U.S. Department of Agriculture Animal and Plant Health Inspection Service through their Chronic Wasting Disease Management and Response Funding Opportunity (USDA 2025) to update the Hazard Model for western contexts. The goal of the proposal was to update the model with ecological and anthropogenic risk factors, geographic features, and cervid species unique to the western US and Canada. Additional proposed advancements to the original Hazard Model included the incorporation of a second model component accounting for baseline risk of CWD introduction based on spatial proximity to other CWD detections and weighting of risk factors by experts.

The goal of the study was to produce an updated hazard model (known as 'Hazard Model 2.0') that accounts for weighted western risk factors in addition to proximity to known CWD detections. The objectives were to: 1) identify all anthropogenic and ecological risk factors that can cause CWD introduction in western jurisdictions; 2) quantify the relative risk associated with each factor; and 3) program the new model into a user-friendly interface in the SOP4CWD Data Warehouse for use with real data by any participating state, provincial, territorial, or Tribal wildlife agency. Hazard Model 2.0 is intended for use by all U.S. and Canadian jurisdictions, as it includes western-relevant risk factors with the previously identified suite of factors identified for eastern and midwestern context.

Methods

Western Guidance Committee and Regional Experts

Project leadership, including researchers from SOP4CWD, U.S. Geological Survey (USGS), and WAFWA, selected and convened a Western Guidance Committee consisting of disease experts with experience managing and researching CWD in western landscapes. The goal of the Western Guidance Committee was to direct project model development and identify western risk factors that would then be evaluated using a larger expert panel. The Western Guidance Committee identified risk factors relevant to CWD introduction in western US states and Canadian provinces, which were then grouped into six categories based on pathway of introduction (natural cervid movement; natural cervid congregation; artificial cervid congregation; business practices with live cervids; business practices with cervid carcasses; and individual human practices). Acknowledging that each risk factor may produce different probabilities of introducing CWD into an area, the Western Guidance Committee recruited an additional panel of western CWD or cervid experts to estimate risk of CWD introduction associated with each factor.

Further acknowledging that the West itself is a diverse landscape, we selected two regions (‘case studies’) to differentiate risks: the Arid Southwest and the Pacific Northwest. The goal of the case studies was to use these two distinct landscapes to test the broad-scale utility of the Hazard Model 2.0, revise the model if any issues were noted, and then provide the general model structure for use in other western regions with minimal need for revisions.

Expert Elicitation Process

The expert elicitation process entailed a sequence of steps involving project leadership and experts, starting with a practice survey followed by three virtual meetings. The goal of this sequence was to produce risk data useful in Hazard Model 2.0.

> <u>Practice Survey.</u> Prior to the first introductory meeting, we provided a practice survey for the experts to complete. The practice survey included four questions that were intended to train the experts on the general structure of the survey questions, help calibrate their estimates, and ultimately improve their ability to respond to the actual questions of interest on the official *CWD Introduction Risk Survey* (detailed below).
>
> <u>Meeting 1.</u> The first virtual meeting was attended by members from both expert panels (Arid Southwest and Pacific Northwest). Project leadership introduced the project, including its purpose, objectives, and associated timelines. Project leaders then discussed the practice survey, their results, and any issues the experts had with survey interpretation or completion. Finally, project leaders introduced the *CWD Introduction Risk Survey* and a supplemental document, which provided definitions and details to reduce linguistic uncertainty. Project leadership disseminated the *CWD Introduction Risk Survey* immediately following the first meeting. Experts were asked to complete the survey individually and not to discuss their responses with other experts. They were allowed to estimate risks using any personal experience, information, and data available to them (details about the *CWD Introduction Risk Survey* below).

Meeting 2. The second virtual meeting consisted of reviewing and discussing the results of the *CWD Introduction Risk Survey* with each region's expert panel separately. During this meeting, project leaders solicited any issues experts faced while completing the survey. Leadership determined whether any parts of the survey needed to be edited for clarity and respondents determined whether any parts of their responses needed to be edited for accuracy. Within each case study region, we identified the greatest estimated risk factors and the risk factors that produced the most variability in estimates among experts.

Meeting 3. In the final meeting, experts from both regions convened with leadership for a full group discussion. Besides presenting next steps of the project and intended products using the results of the *CWD Introduction Risk Survey*, we compared estimates between the two case study regions, further investigated the top few risk factors that produced the greatest variability, discussed potential reasons for that variability, and examined possible methods to reduce variability.

CWD Introduction Risk Survey

Experts used the *CWD Introduction Risk Survey* to estimate the likelihood of each factor introducing CWD into a jurisdiction within one of two case study regions that aligned with their region of expertise (i.e., the Arid Southwest or Pacific Northwest). For both case studies, we asked experts to estimate the number of new CWD infections in a hypothetical and representative management unit in the case study region that would result from the presence of each risk factor during a five-year timeframe. We recognize that there is variation in resident species, their densities, and other factors within an ecoregion, which can lead to different estimates. Furthermore, recognizing that this estimate is dependent on the proximity to nearest CWD detections, we asked experts to consider two distance-based scenarios. The first scenario assumed that CWD had been detected in free-ranging and/or captive cervids within the typical range that resident cervids move annually ('closer scenario'). The second scenario assumed that the nearest detection of CWD was beyond the typical range of cervid movements ('farther scenario'). For both scenarios, we asked experts to imagine a typical area in their respective ecoregion that is inhabited by a population of 1,000 cervids. Project leadership collected all responses in a Qualtrics format, then analyzed the results.

Hazard Model 2.0

The final Hazard Model 2.0 contains CWD risk factors and weights identified by experts through the elicitation process and *CWD Introduction Risk Survey*. These risk factors and weights were combined with a baseline introduction risk produced for each unit based on spatial proximity to reported detections of CWD. The baseline risk from spatial proximity (hereafter, baseline risk) was computed by project investigators independently of the expert survey using publicly available datasets. Specifically, project investigators used the calendar year of first detection reported at the county or management unit level by wildlife agencies across the US and Canada between 1997 and 2025 (APHIS 2025, NDA 2025, CDC 2025, USGS 2025) to compute the annual probability of CWD detection by distance (km) to the nearest reported CWD detection.

Lastly, we explored how variability in expert-provided estimates affected model results by conducting a sensitivity analysis. Specifically, we assessed how the total risk of CWD introduction for a management unit changed depending on: (1) spatial proximity to other detections (i.e., 'closer' versus 'farther' distance-based scenario estimates), and (2) values used for risk factors with the most variable estimates provided by experts. For the latter, we assessed the changes in model outputs using the minimum, maximum, or mean estimate provided by experts for the three factors with the greatest variability. For both sensitivity analyses, we used a model structure incorporating the three most variable risk factors (instead of the full suite, for simplicity) and an arbitrarily generated spatial unit. For brevity, we illustrate results for the Arid Southwest.

Results

Western Guidance Committee and Regional Experts

The Western Guidance Committee, consisting of six disease experts with experience managing or researching CWD in western landscapes (Table 1), identified 20 risk factors relevant to CWD introduction in western U.S. states and Canadian provinces (Table 2). The Western Guidance Committee assisted principal investigators in identifying and recruiting a panel of 13 additional western CWD or cervid experts (Table 1) to estimate risk of CWD introduction for each factor. Thereby, a total of 19 experts were invited to participate in this project to estimate the likelihood of each risk factor introducing CWD.

CWD Introduction Risk Survey

Arid Southwest. Eight experts responded to our survey and provided risk estimates for the Arid Southwest. For the 'closer' scenario (where CWD was assumed to be within average annual movement distance of cervids, although experts were not asked to identify or estimate this distance explicitly), Arid Southwest experts estimated that captive cervid facilities (median=20.0, mean=30.8, SD=11.3) and feedgrounds (median=17.5, mean=30.9, SD=14.5) resulted in the most CWD infections over five years (Table 3). Baiting cervids (e.g., piles, stations) was estimated to cause the third greatest number of infection events (median=17.5, mean=26.6, SD=14.3). Alternatively, for the 'farther' scenario (when CWD was farther than the average cervid could move in a year), Arid Southwest experts estimated that captive cervid facilities result in the highest number of infections (median=17.5, mean=28.5, SD=11.9), followed by the importation and dumping of carcasses or carcass waste into the environment (median=10.0, mean=17.4, SD=9.1; Table 4).

Pacific Northwest. Seven respondents provided risk estimates for the Pacific Northwest. For the 'closer' scenario, Pacific Northwest experts estimated that feedgrounds would result in the greatest number of CWD infection events when CWD detections were 'closer' (median=50.0, mean=73.6, SD=28.2; Table 3). Compared to the Arid Southwest, the Pacific Northwest experts estimated that baiting (median=50.0, mean=46.3, SD=15.2) and the importation and dumping of carcass waste into the environment (median=10.0, mean= 49.3, SD=28.3) would result in more CWD infections than captive cervid facilities (median=10.0, mean=8.9, SD=2.7) when CWD detections were 'closer' (Table 3). For the 'farther' scenario, Pacific Northwest experts estimated captive cervid facilities (median=10.0, mean=8.4, SD=2.8) and the importation and dumping of carcasses or carcass waste into the environment (median=5.0, mean=22.0, SD=13.3) as the greatest risk factors for CWD infections (Table 4).

Variability in Estimates. Expert estimates varied considerably by risk factor and case study region, as noted by reported SE and robust SE values (Tables 3, 4). Within their region, Arid Southwest experts produced the most variability in risk estimates for captive cervid facilities regardless of whether CWD was near or far, with robust standard errors of 8.4 ('closer') and 8.1 ('farther;' Tables 3, 4). When CWD detections were 'closer,' Arid Southwest experts produced the second and third greatest variabilities for feedgrounds and bait (4.7 and 3.7, respectively; Table 3). When CWD detections were 'farther,' importation and dumping of carcasses into the environment also produced a relatively large variability among Arid Southwest estimates (4.7; Table 4).

The Pacific Northwest experts produced more variable estimates within their region than Arid Southwest experts (Tables 3, 4). Pacific Northwest experts produced the greatest variability for feedgrounds (22.4) in the 'closer' scenario and for captive cervid facilities (4.5) in the 'farther' scenario (Table 3). In the Pacific Northwest, baiting produced the second greatest variability regardless of distance to CWD infection ('closer'=21.3, 'farther'=2.2; Tables 3, 4).

Collectively, the experts agreed that whenever a risk factor produced high variability, the variability was reflective of their collective knowledge and experiences. In other words, respondents stood by their responses, even when they collectively produced wide standard errors. Suggested reasons for the greater variability in some factor estimates included sparse or limited data and knowledge and inconsistencies due to localized contexts. We did not investigate whether the variability arose from the qualitative designation of geographic areas to consider (i.e., ecoregions) instead of standardizing specific areas and populations for which to estimate risks. In combination, these findings suggest that future applications of the risk survey could focus on smaller geographical areas (e.g., states, provinces, or regions therein), where expectations about CWD dynamics are likely less variable than at a regional scale. These findings also emphasize that increased data collection could fill in gaps in perceptions by experts.

<u>Sensitivity Analysis.</u> The three risk factors with the most variable estimates among Arid Southwest responses and the 'closer' distance-based scenario were captive cervid facilities, feedgrounds, and baiting. For simplicity, we gave each a score of one [i.e., one captive facility, one feedground, and the presence (or one instance) of baiting in each cell] to conduct our sensitivity analysis. To assess how geographic proximity of CWD would affect model results if all other parameters are held constant, we created two scenarios: one that applied the 'closer' distance-based scenario estimates and one that applied the 'farther' estimates. Table 5 depicts how the baseline spatial proximity risk, CWD introduction risk factor, and model risk scores increased with increased proximity to other CWD detections.

To assess how variability in expert estimates of the three most variable CWD introduction risk factors affected model output, we used the same model structure as above but varied the expert-derived estimates for each in a one-at-a-time manner. Table 6 depicts how model output changed when applying the mean, minimum, and maximum estimates for each factor and the 'closer' distance-based scenario provided by Arid Southwest experts.

We found that total risk of CWD introduction into a management unit changed by up to 19% depending on which estimate (i.e., mean, maximum, or minimum) was used, and this change was fairly consistent for each of the three most variable risk factors. These results indicate that none of the assessed risk factors disproportionately drive total introduction risk, and it may be of benefit for wildlife managers in the Arid Southwest to improve their estimates for all three risk factors. We expect more substantial changes in total risk when applying Pacific Northwest estimates, given Pacific Northwest experts had greater variation in their estimates, and some may result in disproportionate risk. We recognize that variability may arise from the interaction of factors, particularly in areas with large and varied geographies, so managers may improve estimates by considering specific and localized areas within their jurisdiction.

<u>Conclusion</u>

The Hazard Model was developed to support North American wildlife managers in making informed, risk-based surveillance decisions for CWD, but was limited in geographical scope to eastern and midwestern U.S. contexts. Our study expanded the model's applicability to account for risk factors unique to and of importance in western North America by (1) applying expert elicitation to quantify risks, and (2) adding a new component that accounts for spatial proximity to CWD detections. As a result, Hazard Model 2.0 provides utility for risk-based CWD surveillance by wildlife agencies across North America.

Project personnel plan to publish Hazard Model 2.0 in a peer-reviewed journal with all contributing experts as coauthors. The planned publication will highlight the two case studies (Arid Southwest and Pacific Northwest), underscoring how local context, such as landscape and cervid behavior, affects CWD introduction risk and, thus, surveillance needs and resource allocation. We also plan to publish software so any agency can use Hazard Model 2.0 to apply risk-based surveillance in their jurisdiction, regardless of their involvement in SOP4CWD. Additionally, Hazard Model 2.0 is currently being programmed into a user-friendly interface in the SOP4CWD CWD Data Warehouse for use by wildlife agencies partnering with SOP4CWD.

Acknowledgments

We thank the expert panelists that contributed their time and expertise to this work (Table 1). The survey described in this information product was organized and implemented by Western Association of Fish and Wildlife Agencies and Cornell University and was not conducted on behalf of the U.S. Geological Survey.

Funding

The work was supported by the U.S. Department of Agriculture through Cornell University, under Federal Award Number AP24WSNWRC00C030. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

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Table 1. Name, affiliation, position, and ecological region of experts who participated in this study. Experts who served on the Western Guidance Committee, which selected the initial set of risk factors to consider, appear **bold**. Additional experts constitute region-specific personnel who generated estimates for CWD introduction risk through the *CWD Introduction Risk Survey*. Names are listed in alphabetical order based on last name.

Name	Affiliation	Position	Ecological Region
Walter Cook	Texas A&M University	Professor	Arid Southwest
Elin Crockett	New Mexico Game & Fish	Wildlife Veterinarian	Arid Southwest
Melia DeVivo	Washington Department of Fish & Game	Ungulate Research Scientist	Pacific Northwest
Orrin Duvuvuei	New Mexico Game & Fish	Deer Program Manager	Arid Southwest
Clint Epps	Oregon State University	Professor	Pacific Northwest
Colin Gillin	**Oregon Department of Fish & Game**	**Wildlife Veterinarian**	**Pacific Northwest**
Levi Heffelfinger	Texas A&M University Kingsville	Professor	Arid Southwest
Anne Hubbs	**Alberta Environment & Parks**	**Senior Wildlife Biologist**	**Greater Plains**
Anne Justice-Allen	Arizona Game & Fish Department	Wildlife Veterinarian	Arid Southwest
Nate LaHue	**Nevada Department of Wildlife**	**Wildlife Veterinarian**	**Arid Southwest**
Camilla Lieske	**Alaska Department of Fish & Game**	**Wildlife Veterinarian**	**Pacific Northwest**
Brandon Munk	California Department of Fish & Wildlife	Wildlife Veterinarian	Arid Southwest, Pacific Northwest
Cait Nelson	British Columbia Ministry of Water, Land & Resource Stewardship	Wildlife Health Biologist	Pacific Northwest
Hunter Reed	**Texas Department of Parks & Wildlife**	**Wildlife Veterinarian**	**Arid Southwest**
Ashley Reeder	**Oregon Department of Fish & Wildlife**	**Chronic Wasting Disease Coordinator**	**Pacific Northwest**
Dan Walsh	U.S. Geological Survey Montana Cooperative Wildlife Research Unit	Unit Leader and Professor	Pacific Northwest
Margaret Wild	Washington State University Pullman	Professor	Pacific Northwest
Liberty Wood	California Department of Fish & Wildlife	Chronic Wasting Disease Research Scientist	Arid Southwest, Pacific Northwest
Sara Wyckoff	Texas Department of Parks & Wildlife	Wildlife Veterinarian	Arid Southwest

Table 2. Risk factors associated with introduction of chronic wasting disease (CWD) in western jurisdictions as identified by the Western Guidance Committee. Risk factors were grouped into risk categories based on introduction pathway. The 'local practices' risk factor functioned as an 'other' category, allowing managers to capture unique activities in their area.

Risk Category	**Risk Factor**
1. Natural cervid movement	Free-ranging cervid dispersal
2. Natural cervid congregation	Mineral licks Water bodies Seasonal migration
3. Artificial cervid congregation	Feed grounds Guzzlers Baiting stations Agricultural practices
4. Business practices with live cervids	Captive cervid facilities Wildlife rehabilitation centers
5. Business practices with cervid carcasses	Taxidermists Venison processors Rendering facilities Incinerators Venison food banks
6. Individual practices	Landfill disposal of imported carcasses Dumping imported carcasses into environment Antler shed collection Roadkill collection Local practices

Table 3. Mean, median, and standard errors of the number of CWD infections estimated to occur in five years for the 'closer' distance scenario. Statistics were calculated from expert estimates for each CWD introduction risk factor obtained through the *CWD Introduction Risk Survey* for the Arid Southwest (Arid SW; n=8) and Pacific Northwest (PNW; n=7) regions. Standard error (SE) represents a statistical standard error, whereas robust SE represents the standard error in the absence of outliers. The CWD introduction risk factors are categorized by introduction pathway (risk category).

Risk category		Risk factor	Mean		Median		SE		Robust SE	
			Arid SW	PNW	Arid SW	PNW	Arid SW	PNW	Arid SW	PNW
Natural cervid movement										
	1	Free-ranging cervid dispersal	12.0	31.4	6.5	20.0	5.6	13.5	1.8	8.4
Natural cervid congregation										
	2	Mineral licks	13.8	13.0	5.0	10.1	8.9	6.3	1.6	2.8
	3	Water bodies	8.4	8.9	2.5	4.0	6.0	5.3	1.0	1.7
	4	Seasonal migration	13.5	33.6	5.0	10.1	8.8	14.8	0.5	2.8
Artificial cervid congregation										
	5	Feedgrounds	30.9	73.6	17.5	50.0	14.5	28.2	4.7	22.4
	6	Guzzlers	15.6	19.9	8.0	5.0	8.6	13.7	2.1	2.2
	7	Baiting stations	26.6	46.3	17.5	50.0	14.3	15.2	3.7	21.3
	8	Agriculture practices	13.0	34.0	4.5	25.0	8.9	13.4	1.3	11.8
Business practices with live cervids										
	9	Captive cervid facilities	30.8	8.9	20.0	10.0	11.3	2.7	8.4	2.8
	10	Wildlife rehabilitation facilities	10.9	5.7	5.0	5.0	5.9	2.6	2.4	1.7
Business practices with cervid carcasses										
	11	Taxidermists	20.4	17.9	5.0	5.0	15	10.8	1.3	1.1
	12	Venison processors	10.4	15.7	3.5	5.0	7.1	9.4	1.0	1.7
	13	Rendering facilities	10.0	18.0	2.5	5.0	7.2	13.7	1.0	2.2
	14	Incinerators	7.5	1.9	0.0	0.0	7.5	1.4	0.0	0.0
	15	Venison food banks	7.6	6.0	0.0	0.0	7.5	3.6	0.0	0.0
Individual human practices										
	16	Landfill disposal of imported carcasses	18.1	19.9	2.5	1.0	15.3	16.8	0.5	0.6
	17	Dumping imported carcasses into environment	16.0	49.3	10.0	10.0	5.3	28.3	3.1	2.8
	18	Antler shed collection	6.4	2.0	0.0	1.0	6.2	1.4	0.0	0.6
	19	Roadkill collection	8.5	8.4	1.5	2.0	6.1	4.5	0.8	1.1
	20	Local practices	8.8	22.6	3.0	1.0	6.0	14.6	1.4	0.6

Table 4. Mean, median, and standard errors of the number of CWD infections estimated to occur in five years for the ‘farther’ distance scenario. Statistics were calculated from expert estimates for each CWD introduction risk factor obtained through the *CWD Introduction Risk Survey* for the Arid Southwest (Arid SW; n=8) and Pacific Northwest (PNW; n=7) regions. Standard error (SE) represents a statistical standard error, whereas robust SE represents the standard error in the absence of outliers. The CWD introduction risk factors are categorized by introduction pathway (risk category).

Risk category		Risk factor	Mean		Median		SE		Robust SE	
			Arid SW	PNW	Arid SW	PNW	Arid SW	PNW	Arid SW	PNW
Natural cervid movement										
	1	Free-ranging cervid dispersal	5.0	3.6	1.5	1.0	2.6	1.3	0.3	0.0
Natural cervid congregation										
	2	Mineral licks	4.1	1.9	0.0	1.0	3.7	0.8	0.0	0.6
	3	Water bodies	2.8	1.9	0.0	1.0	2.5	0.7	0.0	0.6
	4	Seasonal migration	4.1	4.6	0.5	5.0	3.7	0.8	0.3	0.0
Artificial cervid congregation										
	5	Feedgrounds	11.9	12.1	2.5	5.0	7.6	6.5	1.3	0.6
	6	Guzzlers	5.2	2.4	1.0	1.0	3.6	1.4	0.5	0.6
	7	Baiting stations	9.8	4.3	1.0	5.0	7.6	1.4	0.5	2.2
	8	Agriculture practices	4.1	3.6	0.5	2.0	3.7	1.3	0.3	0.6
Business practices with live cervids										
	9	Captive cervid facilities	28.5	8.4	17.5	10.0	11.9	2.8	8.1	4.5
	10	Wildlife rehabilitation facilities	6.5	2.3	3.0	1.0	2.7	0.9	1.6	0.6
Business practices with cervid carcasses										
	11	Taxidermists	10.1	6.0	2.5	2.0	7.9	3.3	1.0	0.6
	12	Venison processors	8.2	4.9	1.0	2.0	6.0	2.7	0.3	0.6
	13	Rendering facilities	8.1	3.9	1.0	1.0	6.0	1.7	0.5	0.6
	14	Incinerators	3.8	0.4	0.0	0.0	3.8	0.3	0.0	0.0
	15	Venison food banks	5.1	3.6	0.0	0.0	5.0	2.8	0.0	0.0
Individual human practices										
	16	Landfill disposal of imported carcasses	11.2	3.6	2.0	1.0	9.1	2.0	1.0	0.6
	17	Dumping imported carcasses into environment	17.4	22.0	10.0	5.0	8.7	13.3	4.7	2.2
	18	Antler shed collection	2.5	0.6	0.0	0.0	2.5	0.3	0.0	0.0
	19	Roadkill collection	3.0	3.6	0.5	1.0	2.4	2.8	0.3	0.6
	20	Local practices	3.8	15.1	1.0	0.0	2.5	14.2	0.5	0.0

Table 5. An example of how baseline spatial proximity risk, CWD introduction risk factor, and model risk scores increased with increased proximity to other CWD detections based on estimates for the Arid Southwest ecoregion.

	Model Risk Score		
	Baseline spatial proximity	CWD introduction risk factors	Total risk
'Closer' distance-based scenario	0.1	88.3	97.1
'Farther' distance-based scenario	0.05	50.2	52.7

Table 6. Results from an example sensitivity analysis of total model risk when applying the mean, minimum, and maximum estimates obtained from experts for each CWD introduction risk factor and the 'closer' distance-based scenario in the Arid Southwest ecoregion. Percent change from mean indicates how much the total model risk score changed after applying a different statistic for each risk factor used in the model.

		Model Risk Score		
Risk Factor	Expert estimate	CWD introduction risk factors	Total risk	Percent change from mean
Captive Cervids				
Mean	30.8	88.4	92.8	
Minimum	19.5	77.1	80.9	-14%
Maximum	42.1	99.7	104.6	12%
Feedgrounds				
Mean	40	88.4	92.8	
Minimum	16.5	73.9	77.6	-19%
Maximum	45.4	102.8	107.9	15%
Baiting				
Mean	26.6	88.4	92.8	
Minimum	12.3	74.1	77.8	-19%
Maximum	40.9	102.7	107.8	14%