Appendix C

Detailed Matrix Factor Descriptions: Name, Source, Description, Extent, Weight Scale, Justification

- Future Climate Resilience RCP 4.5 – 2040
- Terrestrial Landscape Resilience
- Distance From Urban Boundary
- Road Density
- Categorical Wildfire Hazard Potential
- Distance from Mule Deer Winter Range
- Annual Average Daily Traffic
- Deer- and Elk-Vehicle Collision Counts
- Oregon Connectivity Assessment and Mapping Project Priority Wildlife Connectivity Areas – All Species & Conservation Recommendation Categories
- Multi-Attribute Polygon
- Existing Wildlife Crossing Structure Project
- Oregon Deer and Elk Crossing Prioritization Project – Matrix Factor Values Summary Table

Future Climate Resilience RCP 4.5 – 2040

Source

U.S. Geological Survey[1] [2]

Description

Raster layer containing current and future resilience class for the Western U.S. derived from methodologies established by Bradford et al. 2019. Site resilience and resistance were quantified using simulated moisture and soil temperature conditions for both current and future climate under all available climate scenarios for the 21st century. More specifically, future resilience from the year 2040 under a projected RCP 4.5 climate scenario was selected for the final decision matrix.

Extent

Resilience class extracted from a given 0.10-milepost on an OHAI.

Weight Scale

Highways East of the Cascade Mountains			
Category	Value	Normalized Value	Weight
Low	-1	0.0297	-0.0297
Moderate	0	0.0297	0
High	1	0.0297	0.0297

[1] Bradford et al., *Climate-Driven Shifts* (2019).

[2] John B. Bradford & Daniel R. Schlaepfer, *Historical and 21st Century Soil Temperature and Moisture Data for Drylands of Western U.S. and Canada* (U.S. Geol. Surv.), 2019), https://www.sciencebase.gov/catalog/item/5cdb058fe4b0ab16db3a83b4 (last visited Oct. 17, 2024).

Highways West of the Cascade Mountains			
Category	**Value**	**Normalized Value**	**Weight**
Low	-1	0.0371	-0.0371
Moderate	0	0.0371	0
High	1	0.0371	0.0371

Justification

Placement of wildlife crossing structures should include evaluation of both current and future ecological conditions that may influence wildlife presence in and around selected locations.[3] Vegetation type, distribution, and biomass all influence animal use patterns, and these factors are largely determined by soil and soil moisture regimes at site-specific scales.[4] [5] [6] Predicted climate change is an important consideration for crossing structure site selection, but climate change will be mediated or moderated by site-specific factors like soil moisture regime.[3] [5] The resilience data layers used here reflect site water balance (and thus water availability to plants) currently and under future climate scenarios and serve as a robust indicator of potential future vegetation change.[5]

[3] Littlefield et al., *Evaluating and elevating* (2024).

[4] Jennifer L. Merems et al., *Measuring Ungulate-Forest Interactions: A Methods Primer*, 13 Journal of Fish and Wildlife Management 576 (2022).

[5] Bradford et al., *Climate-Driven Shifts* (2019).

[6] Jay Skolvin & David Thoma, *Interactions underfoot: The Subtle Influence of Soil Moisture on Vegetation Pattern*, 32 Park Science 60 (2015).

Terrestrial Landscape Resilience

Source

The Nature Conservancy[7] [8] [9]

Description

Raster layer representing site resilience at a 30 m resolution. This layer was produced as a component of the resilient and connected network (RCN) and Resilient Land Mapping tool generated by The Nature Conservancy. Resiliency was measured as a function of topographic variability (e.g., high landscape diversity) and its associated climate (i.e., topoclimate), and the degree of human disturbance for a 30 m given cell.

Extent

Percent raster cells classified as *most*, *more*, and *slightly more resilient* extracted from within a 1.5 km (0.93 mi) buffer surrounding a given 0.10-milepost on an OHAI.

Weight Scale

Highways East of the Cascade Mountains			
Category	**Value**	**Normalized Value**	**Weight**
< 50% more/most resilient within 1.5 km (0.93 mi) buffer	0	0.0297	0
> 50% more/most resilient within 1.5 km (0.93 mi) buffer	1	0.0297	0.0297

Highways West of the Cascade Mountains			
Category	**Value**	**Normalized Value**	**Weight**
< 50% more/most resilient within 1.5 km (0.93 mi) buffer	0	0.0371	0
> 50% more/most resilient within 1.5 km (0.93 mi) buffer	1	0.0371	0.0371

[7] Mark G. Anderson et al., *A Resilient and Connected Network of Sites to Sustain Biodiversity Under a Changing Climate*, 120 PNAS e2204434119 (2023).

[8] The Nature Conservancy [TNC], *Resilient Sites (Terrestrial and Coastal)* (2022), https://tnc.maps.arcgis.com/home/item.html?id=2b0ff2a8fb5340a5a5e91ff9c185aa1d (last visited Oct. 30, 2024).

[9] The Nature Conservancy [TNC], *Resilient and Connected Network: Downloads.* https://www.conservationgateway.org/ConservationPractices/ClimateChange/Pages/RCN-Downloads.aspx (last visited July 16, 2025).

Justification

As previously discussed in the Future Climate Resilience matrix factor justification, the placement of wildlife crossing structures should consider both current and future ecological conditions that may affect wildlife presence in and around potential locations.[10] The Terrestrial Resilience layer was added to the matrix alongside future climate resilience because it addresses a different aspect of ecological resilience, such as the intensity of human-driven disturbances and variations in local climate conditions.[11] This layer provides more detailed, site-specific information, enhancing the overall resilience assessment.

[10] Littlefield et al., *Evaluating and elevating* (2024).

[11] Anderson et al., *A Resilient and Connected Network* (2023).

Distance From Urban Growth Boundary

Source

Oregon GEOHub[12] [13]

Description

Spatial layer containing current urban growth boundary (UGB) polygons as identified by Oregon GEOHub. Urban growth boundaries are defined by the state of Oregon as discrete areas of anticipated community growth within a 20-year period.

Extent

Distance from a 1.5 km buffer from the nearest UGB associated with a given 0.10-milepost on an OHAI.

Weight Scale

Highways East of the Cascade Mountains			
Category	**Value**	**Normalized Value**	**Weight**
< 1.5 km (0.93 mi) from UGB	0	0.0219	0
> 1.5 km (0.93 mi) from UGB	1	0.0219	0.0219

Highways West of the Cascade Mountains			
Category	**Value**	**Normalized Value**	**Weight**
< 1.5 km (0.93 mi) from UGB	0	0.0264	0
> 1.5 km (0.93 mi) from UGB	1	0.0264	0.0264

[12] Dep't of Land Conservation & Dev. [DLCD], *Urban Planning: UGBS and Urban/Rural Reserves* (n.d.), https://www.oregon.gov/lcd/up/pages/ugbs-and-urbanrural-reserves.aspx (last visited Sept. 17, 2024).

[13] GEOHub, *Urban Growth Boundaries*, Oregon GIS Framework (2022), https://geohub.oregon.gov/datasets/oregon-geo::urban-growth-boundaries/about (last visited Sept. 16, 2024).

Justification

Human disturbance, including development, impacts animal movement and distribution.[14] [15] For highly mobile organisms like ungulates, disturbance can alter migratory behavior such as increased migration speed, development avoidance, and potential alteration and displacement of migratory routes.[15] [16] [17] Wildlife passage projects should be situated in areas where anthropogenic disturbance and subsequent landscape conversion are limited.[18] Urban growth boundaries (UGBs) were selected to represent human disturbance as they are considered areas with relatively low habitat value and likely future habitat loss resulting from anticipated community growth within a discrete margin.[19] [20] As such, locations greater than 1.5 km away from a UGB are given priority for potential wildlife crossing structure placement.

[14] David B. Lindenmayer & Joern Fischer, *Chapter 2: How Landscapes Change in* Habitat Fragmentation and Landscape Change: An Ecological and Conservation Synthesis 15 (David B. Lindenmayer & Joern Fischer, eds., 2006).

[15] Hall Sawyer, Mallory. S. Lambert & Jerod. A. Merkle. Migratory Disturbance Thresholds with Mule Deer and Energy Development. 84 The J. Wildl. Mgmt. 930 (2020).

[16] Hall Sawyer et al., *A Framework for Understanding Semi-Permeable Barrier Effects on Migratory Ungulates*, 50 J. Appl. Ecol., 68 (2013).

[17] T. B. Wycoff et al., *Evaluating the Influence of Energy and Residential Development on the Migratory Behavior of Mule Deer.* 9 Ecosphere e02113 (2018).

[18] Anthony P. Clevenger & Marcel P. Huijser, *Wildlife crossing structure handbook design and evaluation in North America* (U.S Dep't of Transp., Fed. Highway Admin., Rsch. Rep. No. FHWA-CFL/TD-11-003, 2011).

[19] Thomas Elmqvist, Wayne C. Zipperer & Burak Güneralp. *Urbanization, Habitat Loss and Biodiversity Decline: Solution Pathways to Break the Cycle in* Routledge Handbook of Urbanization and Global Environmental Change 139 (Karen Seta, William D. Solecki & Corrie A. Griffith, eds., 2016).

[20] Department of Land Conservation and Development [DLCD], *UGBs and Urban/Rural Reserves,* https://www.oregon.gov/lcd/up/pages/ugbs-and-urbanrural-reserves.aspx (last visited July 17, 2025).

Road Density

Source

Multi-Resolution Land Characteristics Consortium[21]

Description

Raster layer representing the percent developed impervious surface for a given 30 m cell across the conterminous United States (CONUS). All road types were identified and classified as either road (1) or non-road (0) in ArcGIS Pro 3.3. The Zonal Statistics tool was employed to determine the percent road in each area based on the number of cells classified as roads divided by the total number of cells in a 1.5 km (0.93 mi) buffer surrounding a given 0.10-milepost. Mileposts with <25% road density within a 1.5 km (0.93 mi) buffer received a factor value of 1, all other mileposts (≥25%) received a factor value of 0.

Extent

Percent Road extracted from within a 1.5 km buffer surrounding a given 0.10-milepost on an OHAI.

Weight Scale

Highways East of the Cascade Mountains			
Category	**Value**	**Normalized Value**	**Weight**
>25% road density within a 1.5 km (0.93 mi) buffer	0	0.0658	0
<25% road density within a 1.5 km (0.93 mi) buffer	1	0.0658	0.0658

Highways West of the Cascade Mountains			
Category	**Value**	**Normalized Value**	**Weight**
>25% road density within a 1.5 km (0.93 mi) buffer	0	0.0910	0
<25% road density within a 1.5 km (0.93 mi) buffer	1	0.0910	0.0910

[21] Multi-Resolution Land Characteristics Consortium [MRLC], *NLCD 2021 Percent Developed Imperviousness (CONUS)*, https://www.mrlc.gov/data (last visited July 16, 2025).

Justification

Roads cause landscape fragmentation, impeding movement and limiting connectivity for many species.[22] Highly mobile animals, like ungulates, are at particular risk of roads due to direct mortality and limited access to critical seasonal habitat.[22] [23] While not all roads have the same level of impact, road density may serve as a proxy for human use, with higher road density having increased potential for human disturbance.[22] Due to this, areas with increased road density are de-emphasized for crossing structure placement.

Factor Considerations

For the OHAI, the percent road density surrounding a given milepost varies greatly due to multiple factors, including topography and proximity to municipalities. To capture road density and assign a distinct highway-based safety factor value, we initially established quartiles for each Highway of Analysis Interest, partitioning the percent road density values extracted from a 1.5 km (0.93 mi) buffer surrounding a 0.10 milepost into four equal parts. However, the distribution of road density values resulted in large numeric ranges for certain quartiles, obscuring the potential influence of the road density factor on deer- and elk-vehicle collisions (DEVCs).

To address this challenge, we generated ten road density categories based on the minimum and maximum values observed for all highways combined. Pivot tables were then used to determine the road density values associated with increased DEVCs. For all highways, DEVCs were observed to be greatest when road density was less than 25%. Consequently, the factor value was altered to a binomial factor where 0.10 mileposts with a road density value of less than 25% within a 1.5 km (0.93 mi) buffer received a value of 1, while all others received a value of 0.

[22] Richard T. Forman & Lauren E. Alexander, *Roads and Their Major Ecological Effects*, 29 Ann. Rev. of Ecol. Systematics 207 (1998).

[23] Rachel E. Wheat & Don. G. Whittaker. *Migration Matters: The Migratory Journeys of Mule Deer in Oregon*. Or. Dep't of Fish & Wildl. (2023).

Categorical Wildfire Hazard Potential

Source

U.S. Forest Service Rocky Mountain Research Station[24] [25]

Description

Raster layer containing Wildfire Hazard Potential, described as a given cell's likelihood of experiencing high-intensity fire, including extreme fire behavior such as crowning and torching. The output can be used to identify areas in the conterminous United States (CONUS) necessitating fuels treatment to decrease potential fire risk. This layer does not account for potential benefits of fire on highly valuable resources. Instead, the layer only accounts for resource losses wherein said losses increase with increasing fire intensity.

Extent

Risk potential was extracted from a 1.5 km (0.93 mi) buffer surrounding a given 0.10-milepost on an OHAI. If the buffered area contained a cell with high-very high wildfire hazard potential, the 0.10-milepost received a value of 0, otherwise it received a value of 1.

Weight scale

Highways East of the Cascade Mountains			
Category	Value	Normalized Value	Weight
Very low - Moderate	1	0.0270	0.0270
High - Very High	0	0.0270	0

Highways West of the Cascade Mountains			
Category	Value	Normalized Value	Weight
Very low - Moderate	1	0.0311	0.0311
High - Very High	0	0.0311	0

[24] Gregory K. Dillon, James Menakis & Frank Fay, *Wildland Fire Potential: A Tool for Assessing Wildfire Risk and Fuels Management*, USDA Forest Serv. Proc., RMRS-P73, at 60-76 (2015).

[25] Gregory K. Dillon et al., *Spatial Datasets of Probabilistic Wildfire Risk Components for the United States (270m)*, 3rd ed. (Forest Serv. Rsch. Data Arch. 2023), https://doi.org/10.2737/RDS-2016-0034-3.

Justification

Fire can result in both positive and negative impacts to wildlife populations and habitat values, depending on fire intensity, spatial extent, fire return interval, and species.[26] [27] High intensity fires are most likely to have negative impacts on habitat values, at least over short (1-5 year) time scales, and are more vulnerable to invasion by annual exotic plant species. [27] [28] Locations with high predicted fire risk are likely to burn in the near future or be prioritized for fuels reduction treatments, both of which can degrade habitat for ungulates.[27] As a result, these areas remain neutral when evaluating potential sites crossing structures.

[26] L. J. Lyon et al., *Chapter 1: Introduction in* Wildland Fire in Ecosystems: Effects of Fire on Fauna 1 (Jane K. Smith ed., 2000).

[27] Mule Deer Working Group. *Fact Sheet 18: Mule Deer and the Effects of Fire* (Western Association of Fish and Wildlife Agencies [WAFWA], 2016).

[28] L.J. Lyon et al., *Chapter 4: Fire Effects on Animal Populations in* Wildland Fire in Ecosystems: Effects of Fire on Fauna 25 (Jane K. Smith ed., 2000).

Distance from Mule Deer Winter Range

Source

Oregon Department of Fish and Wildlife[29] [30]

Description

Polygon spatial layer representing mule deer winter range extent in eastern Oregon. Winter range is defined by ODFW as a habitat area typically occupied by migratory deer from December through April. Boundaries were identified based on current and historic data, including an extensive review of mapped winter range from internal and external sources. Quartiles established as proposed values were generated from known maximum mule deer migration distances (km) associated with eastern Oregon herds as published in Ungulate Migrations of the Western United States, Volumes 4 & 5.[31] [32] This factor is not available for highways west of the Cascade Mountains, except for the eastern portion of the Santiam Highway beginning at the Santiam Junction beginning at milepost 74.9.

Extent

Distance from ODFW designated winter range habitat boundary in eastern Oregon for a given 0.10-milepost on an OHAI located east of the Cascade Mountains, including the eastern portion of the Santiam Highway from ODOT mileposts 74.9 – 100.

[29] Chris Cowin, Or. Dep't of Fish & Wildl. [ODFW] *Oregon Big Game Winter Habitat* (2013), https://nrimp.dfw.state.or.us/DataClearinghouse/default.aspx?pn=ViewFile&att=ODFW/ODFW_885_3_Final%202013%20ODFW%20Big%20Game%20Winter%20Habitat%20Map%20Rationale%20%209_6_13.pdf (last visited Sept. 17, 2024).

[30] Cowin, Or. Dep't of Fish and Wildl. [ODFW] *Deer and Elk Winter Range for Eastern Oregon* (2013).

[31] Matthew Kauffman et al., *Ungulate Migrations of the Western United States, Volume 4* (U.S. Geol. Surv. Sci. Investig. Rep. 2024-5006, 2024).

[32] Matthew Kauffman et al., *Ungulate Migrations of the Western United States, Volume 5* (U.S. Geol. Surv. Sci. Investig. Rep 2024 – 5111, 2025).

Weight Scale

Highways East of the Cascade Mountains			
Category	**Value**	**Normalized Value**	**Weight**
1st Quartile: ≤ 34.1 km	2	0.1353	0.2705
2nd Quartile: ≤ 73.2 km	1	0.1353	0.1353
3rd Quartile: ≤ 105.7 km	0	0.1353	0
4th Quartile: ≤ 144.7 km	-1	0.1353	-0.1353

Justification

Winter habitat and connectivity to winter range is essential for ungulate distribution, abundance, and survival.[33] These areas provide hiding and thermal cover, forage, and refuge from human-disturbance.[33] Given that ungulates require access to winter range and highways may be a barrier to that access, mileposts most proximal to winter range are highlighted for ungulate crossing structure placement, with decreasing emphasis as distance from winter range increases.[33] [34]

Factor Value Updates

Ungulate Migrations of the Western United States Volume 5[35] was in review and in the process of publication, and unavailable during the initial development of the ODECPP matrix factors. Consequently, factor values were derived from the maximum known mule deer migration distances for eastern Oregon herds, as documented in *Ungulate Migrations of the Western United States Volume 4.*[36] Upon the release of the new volume, maximum migration distance quartiles were recalculated, incorporating data for multiple mule deer herds associated with OHAI east of the Cascade Mountains.

[33] Corwin, *Oregon Big Game Winter Habitat* (2013).

[34] Wheat & Whittaker. *Migration Matters* (2023).

[35] Kauffman et al., *Ungulate Migrations Volume 5* (2025).

[36] Kauffman et al., *Ungulate Migrations Volume 4* (2024).

Annual Average Daily Traffic

Source
Oregon Department of Transportation[37]

Description
Point layer quantifying deer- and elk-vehicle collision risk as a function of Annual Average Daily Traffic (AADT) category values. The values assigned to distinct AADT categories were derived from the frequency of deer and elk carcasses per 0.10 milepost recorded between 2020 and 2023 for each OHAI.

To generate a factor value, the Jenks natural breaks formula was applied to each Highway of Analysis Interest. We aimed for a desired break level of seven to correspond with the categories generated for The Dalles-California Highway; however, most highways only had large enough ranges for six natural breaks, with Santiam East producing the least with three total natural breaks. These natural breaks were then converted into whole numbers for each highway. Categories (e.g., 1-7) were developed to represent a range of values based on the natural breaks. Pivot tables were created to generate the sums of DEVCs per AADT category for each highway, allowing discernment of the amount of DEVCs per AADT level.

- AADT categories associated with ≥50 carcasses during the analysis period (2020-2023) were assigned a factor value of 0.5.
- AADT categories associated with ≥100 carcasses were assigned a factor value of 1.0.
- AADT categories associated with ≥200 carcasses were assigned a factor value of 2.0.

Extent
Annual Average Daily Traffic range category associated with a given 0.10-milepost on an OHAI.

[37] Or. Dep't of Transp. [ODOT], *ODOT TransGIS Annual Average Daily Traffic (AADT) – State* (2024), https://gis.odot.state.or.us/transgis (last visited Sept. 17, 2024).

Annual Average Daily Traffic Factor Weight

Highways East of Cascade Mountains

The Dalles-California Highway (HWY004)			
Category	**Value**	**Normalized Value**	**Weight**
AADT per 0.10 MP < 5,000	2	0.1304	0.2608
AADT per 0.10 MP < 10,000	2	0.1304	0.2608
AADT per 0.10 MP < 15,000	1	0.1304	0.1304
AADT per 0.10 MP < 20,000	0.5	0.1304	0.0652
AADT per 0.10 MP < 25,000	0	0.1304	0
AADT per 0.10 MP < 30,000	0.5	0.1304	0.0652
AADT per 0.10 MP > 30,000	2	0.1304	0.2608

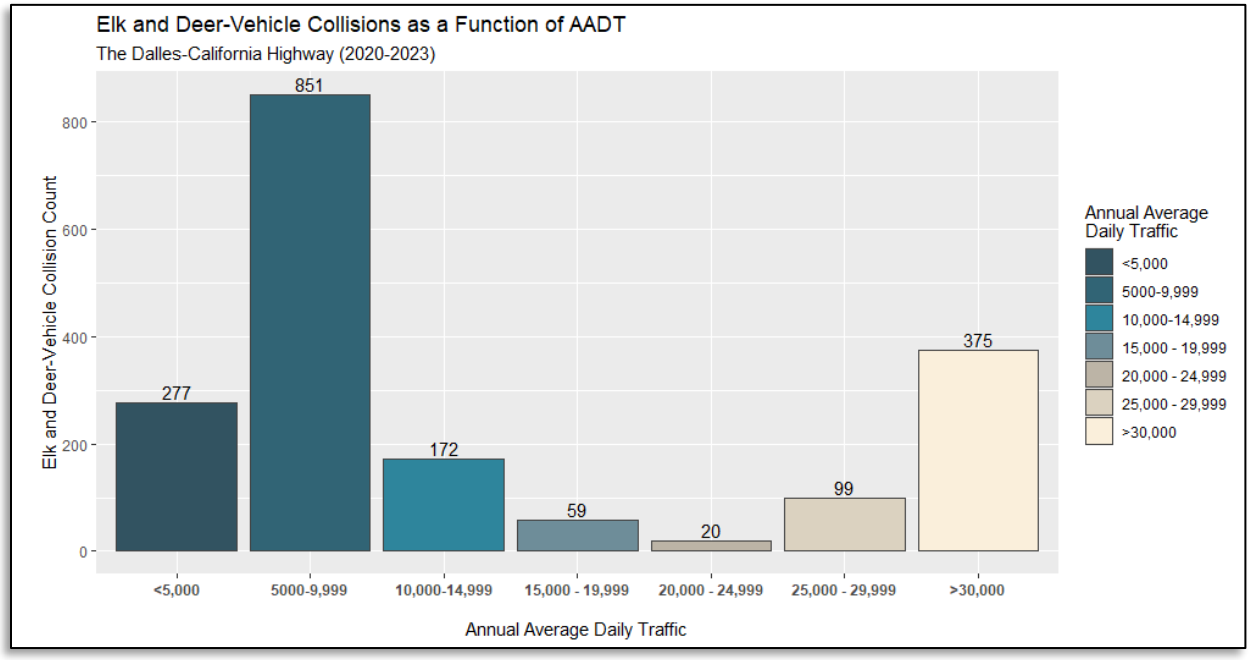


Figure A.C. 1 Elk and Deer-Vehicle Collisions (2020–2023) Relative to Annual Average Daily Traffic (AADT) on The Dalles-California Highway.

Old Oregon Trail Highway (HWY006)			
Category	**Value**	**Normalized Value**	**Weight**
AADT per 0.10 MP < 12,000	2	0.1304	0.2608
AADT per 0.10 MP < 14,000	2	0.1304	0.2608
AADT per 0.10 MP < 16,000	0.5	0.1304	0.0652
AADT per 0.10 MP < 18,000	0	0.1304	0
AADT per 0.10 MP < 20,000	1	0.1304	0.1304
AADT per 0.10 MP > 20,000	0	0.1304	0

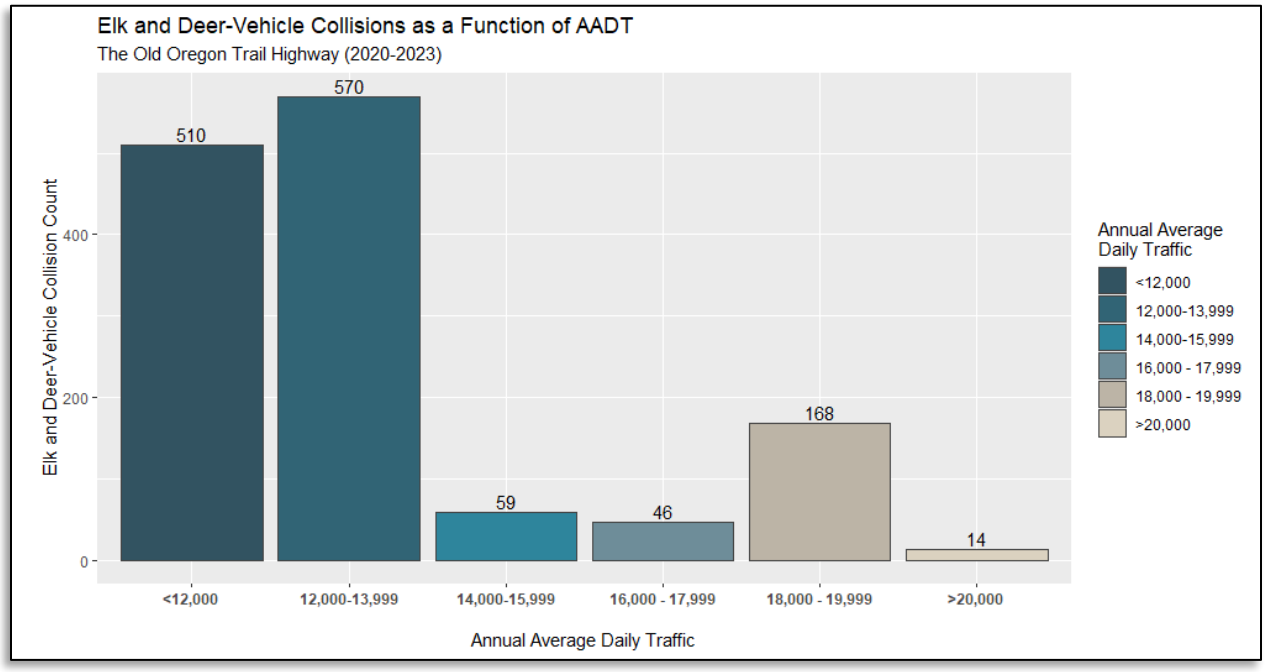


Figure A.C. 2. Elk and Deer-Vehicle Collisions (2020–2023) Relative to Annual Average Daily Traffic (AADT) on The Oregon Trail Highway.

Central Oregon Highway (HWY007)			
Category	**Value**	**Normalized Value**	**Weight**
AADT per 0.10 MP < 2,000	2	0.1304	0.2608
AADT per 0.10 MP < 4,000	2	0.1304	0.2608
AADT per 0.10 MP < 6,000	0.5	0.1304	0.0652
AADT per 0.10 MP < 8,000	0	0.1304	0
AADT per 0.10 MP < 10,000	0	0.1304	0
AADT per 0.10 MP > 10,000	0	0.1304	0

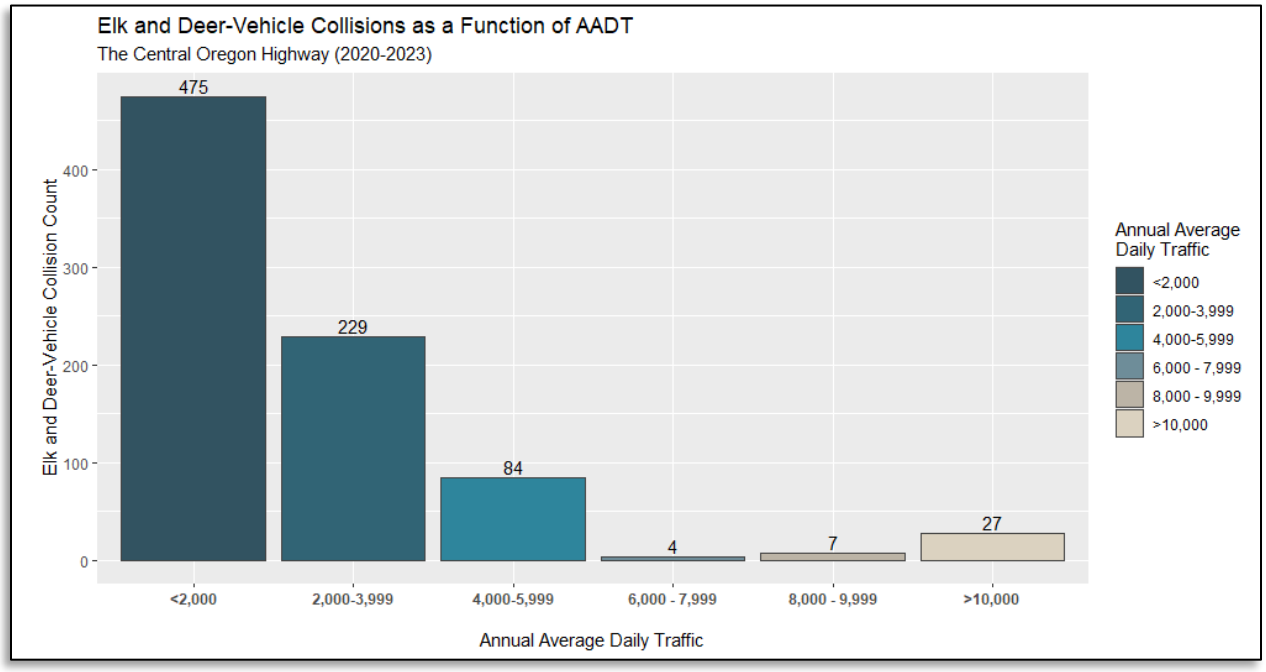


Figure A.C. 3. Elk and Deer-Vehicle Collisions (2020–2023) Relative to Annual Average Daily Traffic (AADT) on The Central Oregon Highway.

Wallowa Lake Highway (HWY010)			
Category	**Value**	**Normalized Value**	**Weight**
AADT per 0.10 MP < 2,000	1	0.1304	0.1304
AADT per 0.10 MP < 4,000	2	0.1304	0.2608
AADT per 0.10 MP < 6,000	0	0.1304	0
AADT per 0.10 MP < 8,000	0	0.1304	0
AADT per 0.10 MP < 10,000	0	0.1304	0
AADT per 0.10 MP > 10,000	0	0.1304	0

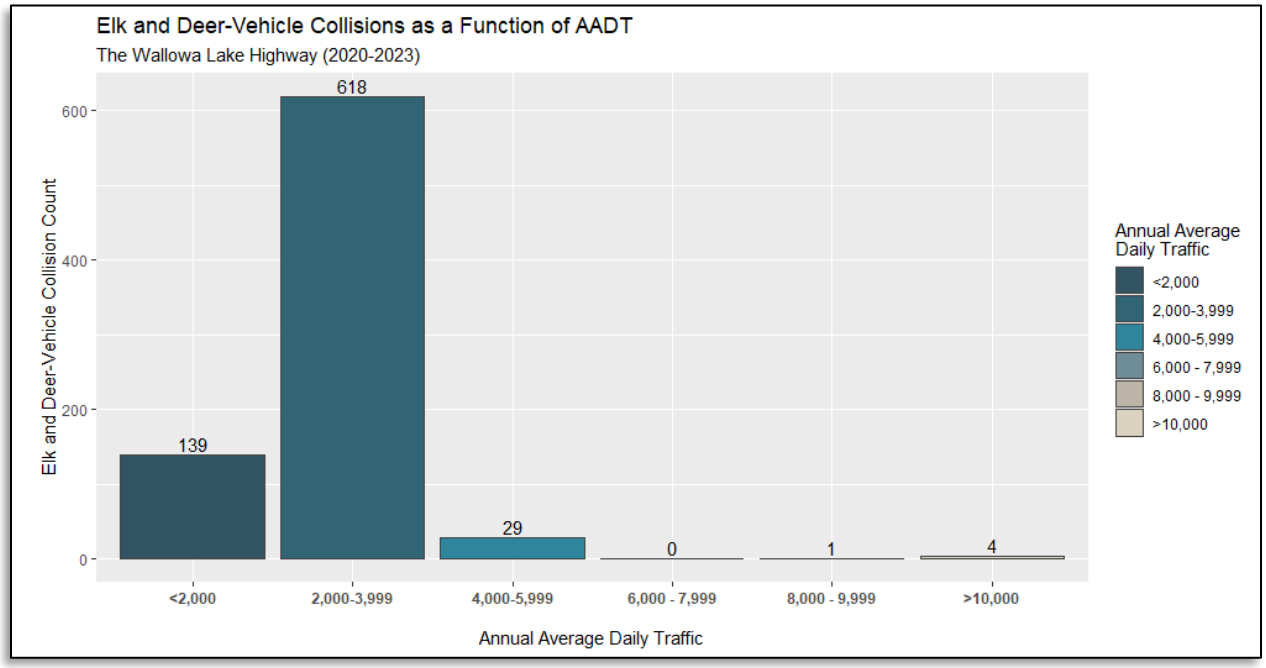


Figure A.C. 4. Elk and Deer-Vehicle Collisions (2020–2023) Relative to Annual Average Daily Traffic (AADT) on The Wallowa Lake Highway.

Santiam East (MP 74.9 - 100) (HWY016)			
Category	**Value**	**Normalized Value**	**Weight**
AADT per 0.10 MP < 6,000	0	0.1304	0
AADT per 0.10 MP < 8,000	0.5	0.1304	0.0652
AADT per 0.10 MP > 8,000	0.5	0.1304	0.0652

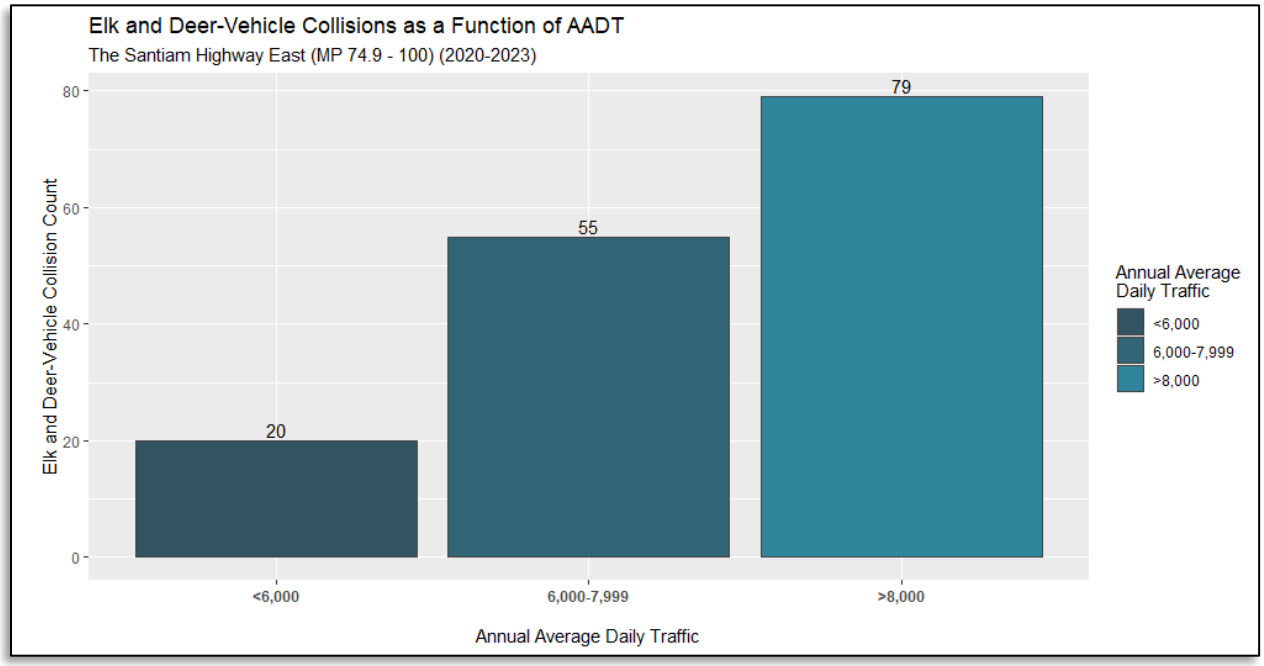


Figure A.C. 5. Elk and Deer-Vehicle Collisions (2020–2023) Relative to Annual Average Daily Traffic (AADT) on The Santiam Highway East (MP 74.9 –100).

Highways West of Cascade Mountains

Pacific Highway (HWY001)			
Category	**Value**	**Normalized Value**	**Weight**
AADT per 0.10 MP < 30,000	2	0.1516	0.3033
AADT per 0.10 MP < 50,000	2	0.1516	0.3033
AADT per 0.10 MP < 70,000	1	0.1516	0.1516
AADT per 0.10 MP < 90,000	0	0.1516	0
AADT per 0.10 MP < 110,000	0	0.1516	0
AADT per 0.10 MP <130,000	0	0.1516	0
AADT per 0.10 MP >130,000	0	0.1516	0

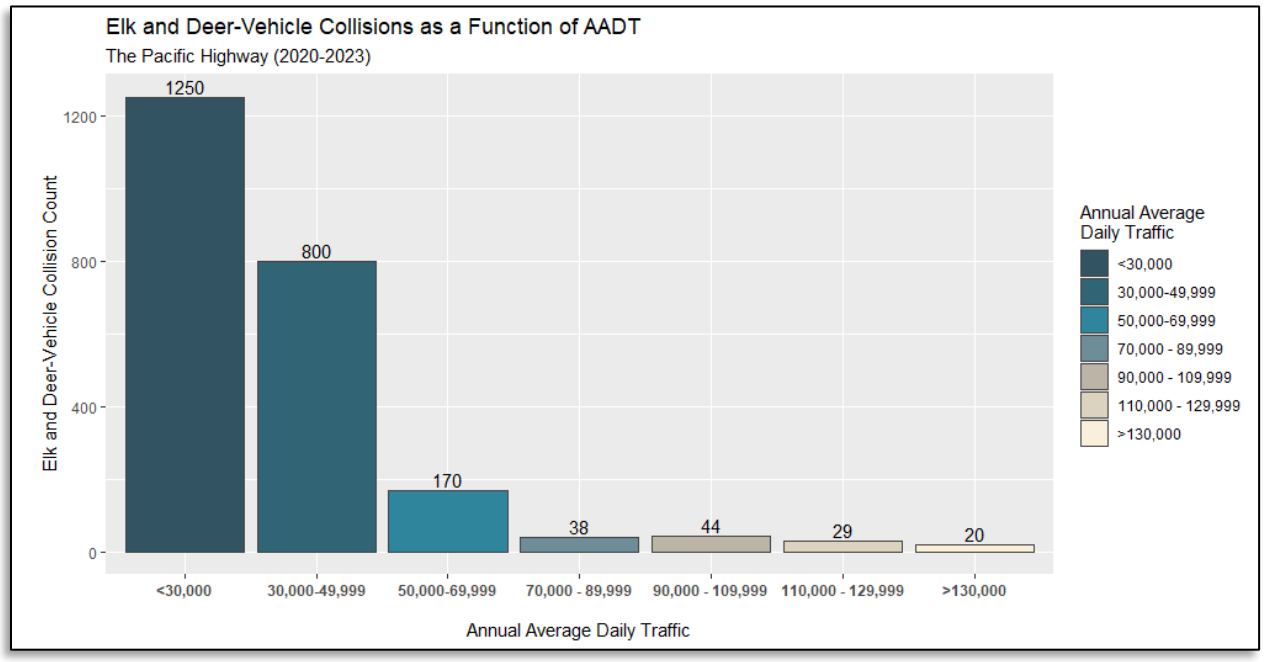


Figure A.C. 6. Elk and Deer-Vehicle Collisions (2020–2023) Relative to Annual Average Daily Traffic (AADT) on The Pacific Highway.

Oregon Coast Highway (HWY009)			
Category	**Value**	**Normalized Value**	**Weight**
AADT per 0.10 MP < 4,000	1	0.1516	0.1516
AADT per 0.10 MP < 6,000	2	0.1516	0.3033
AADT per 0.10 MP < 8,000	1	0.1516	0.1516
AADT per 0.10 MP < 10,000	0.5	0.1516	0.0758
AADT per 0.10 MP < 20,000	2	0.1516	0.3033
AADT per 0.10 MP > 20,000	0.5	0.1516	0.0758

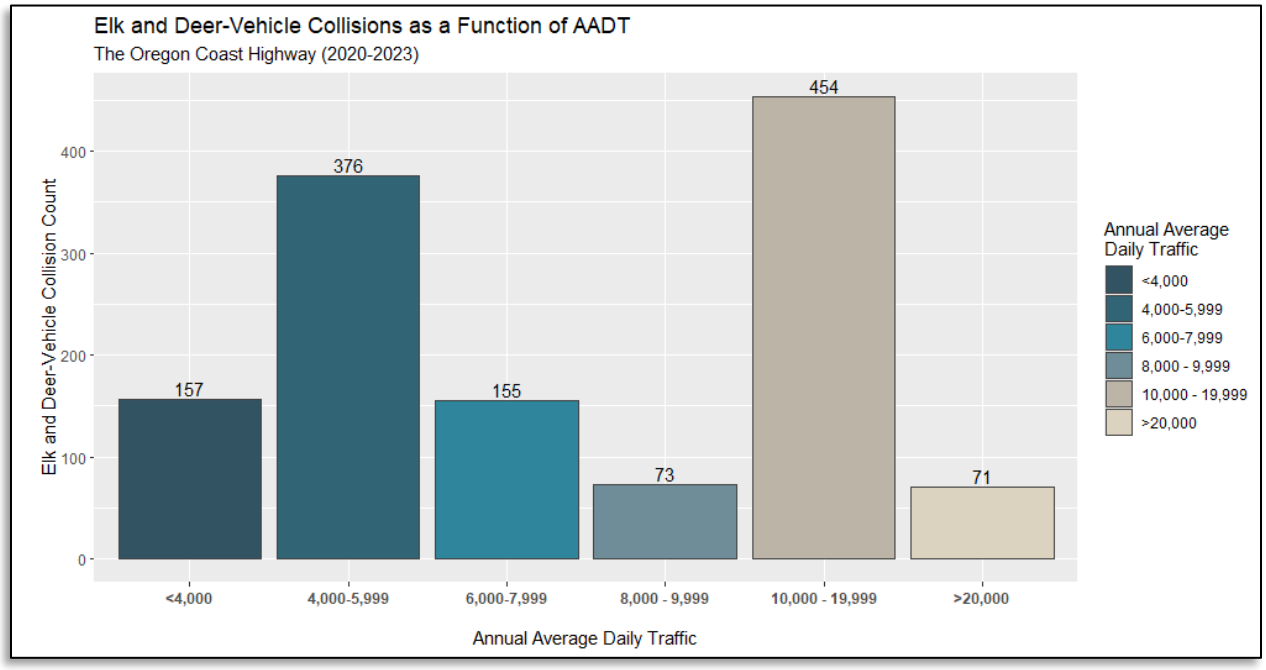


Figure A.C. 7. Elk and Deer-Vehicle Collisions (2020–2023) Relative to Annual Average Daily Traffic (AADT) on The Oregon Coast Highway.

Santiam (MP 0.0 – 74.8) (HWY016)			
Category	**Value**	**Normalized Value**	**Weight**
AADT per 0.10 MP < 2,000	0	0.1516	0
AADT per 0.10 MP < 4,000	0	0.1516	0
AADT per 0.10 MP < 6,000	0	0.1516	0
AADT per 0.10 MP < 8,000	0	0.1516	0
AADT per 0.10 MP < 10,000	0	0.1516	0
AADT per 0.10 MP > 10,000	1	0.1516	0.1516

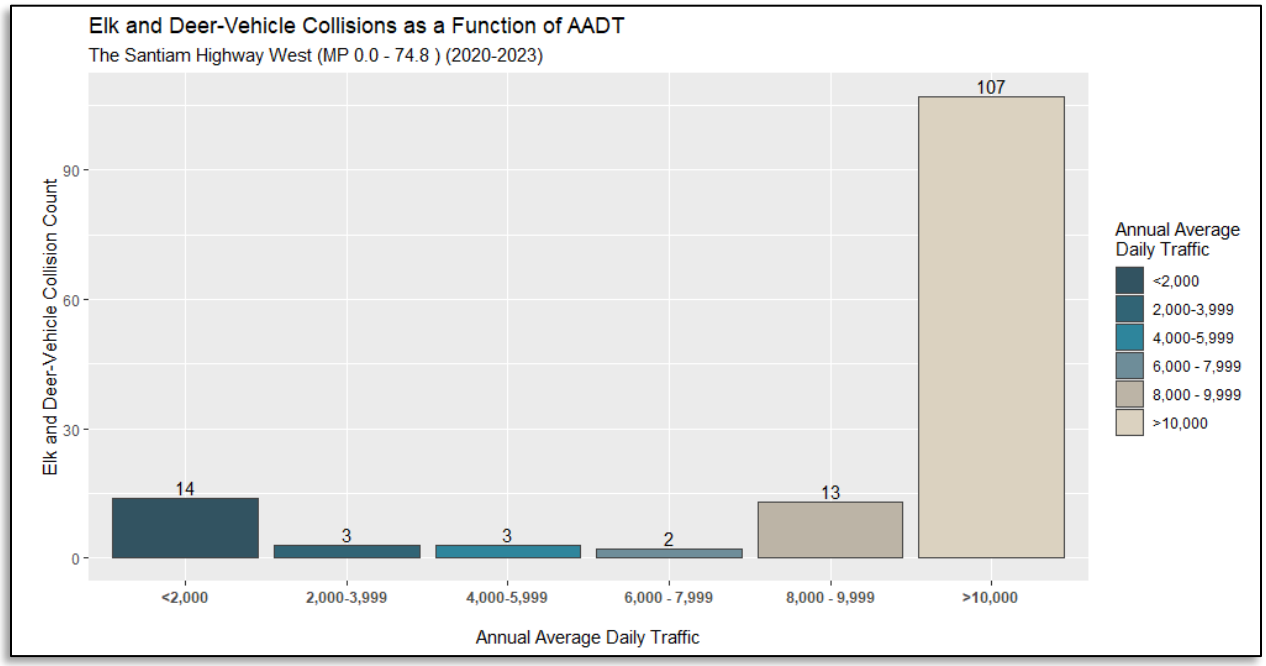


Figure A.C. 8. Elk and Deer-Vehicle Collisions (2020–2023) Relative to Annual Average Daily Traffic (AADT) on The Santiam West Highway (MP 0.0- 74.8).

Justification

Traffic volume, measured as Annual Average Daily Traffic (AADT), is commonly used as a predictor variable in models assessing the influence of wildlife-vehicle collisions.[38] [39] However, it has not consistently demonstrated predictive reliability. Critics of its use point to the dynamic nature of traffic patterns and the difficulty of capturing exact traffic volumes at the time of a collision.[38] Despite these limitations, the exploratory data analysis conducted for the ODECPP indicated that certain traffic volumes ranges were more strongly associated with deer- and elk-vehicle collisions (DEVCs) than others. While a uniform set of traffic volume categories might be desirable for matrix-factor standardization, each Oregon Highway of Analysis Interest (OHAI) exhibits a distinct traffic volume profile. Accordingly, DEVC patterns and trends vary in relation to highway-specific traffic volume ranges. When analyzed using uniform traffic volume categories across highways, raw DEVC counts may not accurately reflect the influence of discrete traffic volumes.

[38] John. A. Bissonette & Christine A. Kassar, *Locations of Deer-Vehicle Collisions*, (2008).

[39] Raphaela Pagany, *Wildlife-Vehicle Collisions – Influencing Factors, Data Collection and Research Methods,* 251 Biol. Conversation 108758 (2020).

Deer- and Elk-Vehicle Collision Counts

Source

Oregon Department of Transportation[40]

Description

Point layer containing total deer- and elk-vehicle collision (DEVCs) counts recorded from 2020-2023 on the seven OHAI. Deer- and elk-vehicle collision counts per 0.10 milepost for the years analyzed (2020-2023) were summed and multiplied by the normalized value to establish a factor weight.

Extent

Total deer- and elk-vehicle collision counts recorded from 2020-2023 for a given 0.10-milepost associated with each OHAI.

Weight Scale

Highways East of the Cascade Mountains			
Category	**Value**	**Normalized Value**	**Weight**
DEVC Sum per 0.10 MP (n)	n	0.2502	n*0.2502

Highways West of the Cascade Mountains			
Category	**Value**	**Normalized Value**	**Weight**
DEVC Sum per 0.10 MP (n)	n	0.2898	n*0.2502

[40] Or. Dep't of Transp. [ODOT], *ODOT TransGIS Animal Incidents* (2024), https://gis.odot.state.or.us/transgis (last visited Sept. 17, 2024).

Justification

Deer- and Elk-Vehicle Collision (DEVC) data represent a spatially explicit indicator of high risk-roadway crossing locations for deer and elk, making them a valuable tool for identifying mitigation opportunities.[41] Deer- and elk-vehicle collisions were included in the OCAMP process as well as the Colorado Western and Eastern Slope and Plains Wildlife Prioritization Studies.[42] [43] [44] Measuring the total number of recent DEVCs per 0.10 milepost indicates areas of greatest concern relative to the entire highway reach. As such areas with higher DEVCs are prioritized for ungulate crossing structure placement with decreasing emphasis as DEVC counts decrease. These data are consistently used in wildlife crossing structure studies and are readily tracked by state departments of transportation.[41]

[41] Shilling & Waetjen, *Wildlife-Vehicle Collision Hotspots* (2015).

[42] Or. Dep't of Fish & Wildl., *Oregon Connectivity Assessment and Mapping Project* (2023).

[43] Kintsch et al., *Western Slope* (2019).

[44] Kintsch et al., *Eastern Slope* (2022).

Oregon Connectivity Assessment and Mapping Project Priority Wildlife Connectivity Areas – All Species & Conservation Recommendation Categories

Source

Oregon Connectivity Assessment and Mapping Project[45] [46]

Description

Forty-acre hexagons representative of high-value connectivity areas across 54 surrogate species were generated by the Oregon Connectivity Assessment and Mapping Project (ODFW, Portland State University, and the Samara Group). The hexagons may signify any combination of four distinct primary or secondary conservation action recommendation categories: Protect, Restore, Transportation Mitigation, Enhance/Maintain. In addition to conservation recommendation categories, there are three types of PWCA hexagons: Regions, Connectors, and Steppingstones.

Extent

Any PWCA hexagon located within a 1.5 km (0.93 mi) buffer surrounding a given 0.10-milepost on an OHAI.

Weight Scale

Highways East of the Cascade Mountains			
Category	Value	Normalized Value	Weight
PWCA hexagon intersect	1	0.0753	0.0753
PWCA hexagon does not intersect	0	0.0753	0

Highways West of the Cascade Mountains			
Category	Value	Normalized Value	Weight
PWCA hexagon intersect	1	0.1003	0.1003
PWCA hexagon does not intersect	0	0.1003	0

[45] Or. Dep't of Fish & Wildl. [ODFW], *Oregon Connectivity Assessment and Mapping Project* (2023).

[46] Or. Dep't of Fish & Wildl. [ODFW], Priority Wildlife Connectivity Areas (2023), https://geo.maps.arcgis.com/home/item.html?id=f25ec2be02134274beab92c2aeb29bdc&view=table&sortOrder=desc&sortField=defaultFSOrder#overview (Last visited Oct. 22, 2024).

Justification

Identifying high-quality habitat and associated movement corridors that provide connectivity across landscapes is essential for maintaining current and future biodiversity.[47] The Priority Wildlife Connectivity Areas (PWCAs) produced by the collaborative Oregon Connectivity Assessment and Mapping Project (OCAMP) employed the best-available data sources and methodologies to identify the top 1% of priority areas, and associated least-cost pathways, for 54 surrogate species.[48] In Oregon, wildlife crossing structures are generally constructed for highly mobile species like ungulates; however, they can provide habitat connectivity for many of Oregon's species. As such, mileposts intersecting with PWCA hexagons are prioritized due to the increased likelihood for multi-species benefits from an ungulate crossing structure.

[47] Jodi A. Hilty et al., *Background: Habitat Loss, Fragmentation, and Climate Change in* Corridor Ecology: Linking Landscapes for Biodiversity Conservation and Climate Adaptation 6 (Hilty et al. eds, 2019).

[48] Or. Dep't of Fish & Wildl. [ODFW], *Oregon Connectivity Assessment and Mapping Project* (2023).

Multi-Attribute Polygon

Source

Oregon Department of Transportation[49], Oregon Department of Fish & Wildlife[50] [51], HERS Lab, OSU-Cascades[52]

Description

The Multi-Attribute Polygon (MAP) combines intersecting points of interest derived from (1) an Optimized Hot Spot Analysis[53], (2) Ungulate Only PWCA hexagons that intersect highways[50], as well as (3) Oregon ungulate movement data (available for highways east of the Cascade Mountains only).[51]

Statistically significant deer-vehicle collision (DVC) hot spots for each ten-mile section of roadway on the OHAI were identified using the Optimized Hot Spot Analysis Spatial Statistics tool in ArcGIS Pro 3.3.0.[54] Deer-vehicle collision counts from ODOT TransGIS from 2016-2023 were snapped to the nearest 0.10-milepost and entered into the analysis field with 0.10-mileposts representing the input feature. Ten-mile segments of highway were selected as the extent as each feature (e.g., 0.10-milepost) and its neighbor is proportionally compared to the sum of all features in the segment provided.[55] Additionally, the tool requires at least 30 records to process.[56] A 0.10-milepost is identified as statistically significant when the local sum varies from what is expected and the sum is too large to be considered due to random chance.[57] The output

[49] Or. Dep't of Transp. [ODOT], *Animal Incidents, ODOT TransGIS* (2024), https://gis.odot.state.or.us/transgis (last visited Sept. 17, 2024).

[50] Or. Dep't of Fish & Wildl. [ODFW], *Priority Wildlife Connectivity Area Highway Overlap Ungulates Only* (2024).

[51] Or. Dep't of Fish & Wildl. [ODFW], *Mule Deer Herd Movement Data*, [Provisional Data Source] Not for public release (2024).

[52]Human and Ecosystem Resilience and Sustainability [HERS] Lab, *Multi-Attribute Polygon Analysis* (2024) (Based on Or. Dep't of Transp, *Animal Incidents* (2016-2023), Or. Dep't of Fish & Wildl., *Ungulate Only PWCAs* (2023), & Or. Dep't of Fish & Wildl., *Mule Deer Herd Movement Data* (2024).

[53] Environmental Research Systems Institute (Esri), n.d., *Optimized Hot Spot Analysis (Spatial Statistics)*, https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-statistics/optimized-hot-spot-analysis.htm (last visited Sept. 12, 2024).

[54] Environmental Research Systems Institute (Esri), ArcGIS Pro 3.3.0 (2022).

[55] Environmental Research Systems Institute (Esri), n.d. *How Hot Spot Analysis (Gets-Ord Gi*) Works*, https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-statistics/h-how-hot-spot-analysis-getis-ord-gi-spatial-stati.htm (last visited Sept. 12, 2024).

[56] Environmental Research Systems Institute (Esri), n.d., *How Optimized Hot Spot Analysis Works,* https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-statistics/how-optimized-hot-spot-analysis-works.htm, (last visited Sept. 12, 2024).

[57] Environmental Research Systems Institute (Esri), *How Hot Spot Analysis (Gets-Ord Gi*) Works*.

generates a new spatial layer with rendered hot and cold spots and provides a G_i^* statistic (z-score) and p-value for all locations analyzed. Z-scores fall between +/- 3.[58] The higher the z-score, the higher the intensity in hot spot clustering.[58] Conversely, the smaller the value the higher the intensity in cold spot clustering.[58] A given location with a z-score of 0 is not considered statistically significant and is not evident of spatial clustering.[58] All mileposts with z-score values of zero and below were removed and not considered for intersection analysis.

While the output identifies areas with spatial clustering of events, it may not assign statistical significance to points with high value if other points of high value are not adjacent. As such, this tool should not be used independently to make priority crossing area decisions, as some mileposts with high vehicle-collision density may be concealed.

Ungulate Species PWCA – Highway Overlap hexagons were selected if they were within 1.5 km (0.93 mi) of a statistically significant hot spot on the highway. Finally, for highways east of the Cascade Mountains, mule deer movement data were added to the map for central and eastern Oregon herds. The truncated PWCA hexagons from the original selection were then further refined based on their proximity to known mule deer movement areas. Any PWCA hexagons from the previously described refinement process within 1.5 km (0.93 mi) of a given area mule deer movement for herds associated with the highway was selected and buffered to generate a series of polygons representing the intersection of these attributes for each OHAI.

Extent

Any MAP polygon intersecting a given 0.10-milepost on an ODOT OHAI.

Weight Scale

Highways East of the Cascades			
Category	**Value**	**Normalized Value**	**Weight**
Intersects MAP	3	0.2100	0.630106
Does not intersect MAP	0	0.2100	0

[58] Environmental Research Systems Institute (Esri), *Optimized Hot Spot Analysis (Spatial Statistics)*.

Highways West of the Cascades			
Category	**Value**	**Normalized Value**	**Weight**
Intersects MAP	2	0.2018	0.403598
Does not intersect MAP	0	0.2018	0

Justification

The Getis-Ord hotspot analysis approach is commonly cited in both transportation agency and peer-reviewed journal publications.[59] [60] Combining hotspot analysis output with PWCA hexagons and utilization distribution data leverages existing work (OCAMP) with taxa-specific spatial data not available during the OCAMP process. Additionally, utilization distribution and hotspot analysis data are reproducible through time, enabling future application to crossing structure location decisions.

[59] Kintsch et al., *Western Slope* (2019).

[60] Kintsch et al., *Eastern Slope* (2022).

Existing Wildlife Crossing Structure Project

Source

Oregon Department of Transportation; HERS Lab, OSU-Cascades

Description

Point spatial layer indicating presence of extant wildlife passage projects at mileposts 149.55, 152.03, 154.40, 180.13, and 183.15, including fencing extents from milepost 149-156 and 178-183.

Extent

Value extracted from 1.5 km (0.93 mi) buffer surrounding a given 0.10-milepost on The Dalles-California Highway.

Weight Scale

Highways East of the Cascades			
Category	Value	Normalized Value	Weight
Passage project intersects	1	0.0247	0.0247
Passage project does not intersect	0	0.0247	0

Highways West of the Cascades			
Category	Value	Normalized Value	Weight
Passage project intersects	1	0.0338	0.0338
Passage project does not intersect	0	0.0338	0

Justification

Peer reviewed literature and monitoring reports indicate that landscape permeability and wildlife crossing structure effectiveness increases with a suite of strategically placed structures, rather than isolated installations, and with fence lengths exceeding 5 kilometers.[61] [62] This is especially true in known ungulate-vehicle collision hotspots.[61] [62] Based on recent monitoring efforts conducted on US-97, Oregon's five existing wildlife crossing structures demonstrate observable fence-end effects, suggesting that the established project boundaries may not correlate with the spatial dimensions of DVC hotspots.[63] Priority is given to existing passage projects, as they would benefit from project modification, including the placement of additional wildlife crossing structures and elongation of fencing extent, until desired success metrics are reached.

[61] John A. Bissonette & William A. Adair. *Restoring Habitat Permeability to Roaded Landscapes with Isometrically-Scaled Wildlife Crossings.* 141 Biol. Conserv. 482 (2008).

[62] Huijser et al., *Effectiveness of Short Sections of Wildlife Fencing* (2016).

[63] Corrinne D. Oedekerk & Matt J. Shinderman. *U.S. South Highway 97 Wildlife Crossing Structure Effectiveness Monitoring – Final Report* (Or. St. Univ. 2024).

Appendix C – ODECPP Detailed Factor Descriptions

Oregon Deer and Elk Crossing Prioritization Project – Matrix Factor Values				
Description	**Scale**			
Future Climate Resilience	Low	Moderate	High	
	-1	0	1	
Terrestrial Resilience	<50% Most/More Resilient		>50% Most/More Resilient	
	0		1	
Wildfire Hazard Potential	Very Low – Moderate		High – Very High	
	1		0	
Urban Growth Boundary	<1.5 km (0.93 mi) from UGB		>1.5 km (0.93 mi) from UGB	
	0		1	
Distance from Winter Range	≤34.1 km	≤73.2 km	≤105.7 km	≤144.7 km
	2	1	0	-1
Annual Average Daily Traffic (DVCs per AADT Category)	<50 DVCs	≥50 DVCs	≥100 DVCs	≥200 DVCs
	0	0.5	1	2
Deer- and Elk-Vehicle Collisions	Deer- and Elk-Vehicle Collision Count per 0.10 MP			
	n per 0.10 MP			
Road Density	≤25%		>25%	
	1		0	
	Intersects		Does not Intersect	
OCAMP PWCA Hexagon	1		0	
Multi-Attribute Polygon (East of the Cascades)	3		0	
Multi-Attribute Polygon (West of the Cascades)	2		0	
Existing WCS Project	1		0	