VIRGINIA WILDLIFE CORRIDOR ACTION PLAN

FINAL

MAY 2023

VIRGINIA WILDLIFE CORRIDOR ACTION PLAN

Making Roads Safer for People and Wildlife

FINAL

MAY 2023

Virginia Department of Wildlife Resources
Virginia Department of Transportation
Virginia Department of Conservation and Recreation
Virginia Department of Forestry

Executive Summary

Virginia is one of the first states in the eastern U.S. to create a *Wildlife Corridor Action Plan* (Plan) with a clear emphasis on protecting vital wildlife habitat corridors and reducing wildlife-vehicle conflicts, such as collisions, to promote driver safety. Wildlife corridors connect fragmented habitats separated by human activities or infrastructure; this habitat connectivity is vital to the long-term sustainability of wildlife biodiversity. When road infrastructure fragments wildlife habitats, some species of wildlife may need to move across roads to reach suitable habitats for fulfilling their food, water, shelter, and mating requirements. Wildlife-vehicle conflicts can occur, resulting in driver safety risks due to direct collisions with the animals or crashes from avoidance maneuvers, as well as wildlife population impacts such as significant mortality and barriers to dispersal. More than 60,000 known deer-vehicle collisions have occurred annually in Virginia since 2015, costing the Commonwealth and its citizens approximately $533 million each year.

To make roads safer for drivers and wildlife, wildlife crash countermeasures are more frequently being integrated into road transportation projects across the nation. For example, one measure is called a wildlife crossing, which is typically a road underpass or overpass specifically designed so wildlife can cross under or over a road. Benefits of integrating wildlife crash countermeasures into roads include safe wildlife passage, wildlife biodiversity resilience, improved driver safety, and reduced costs.

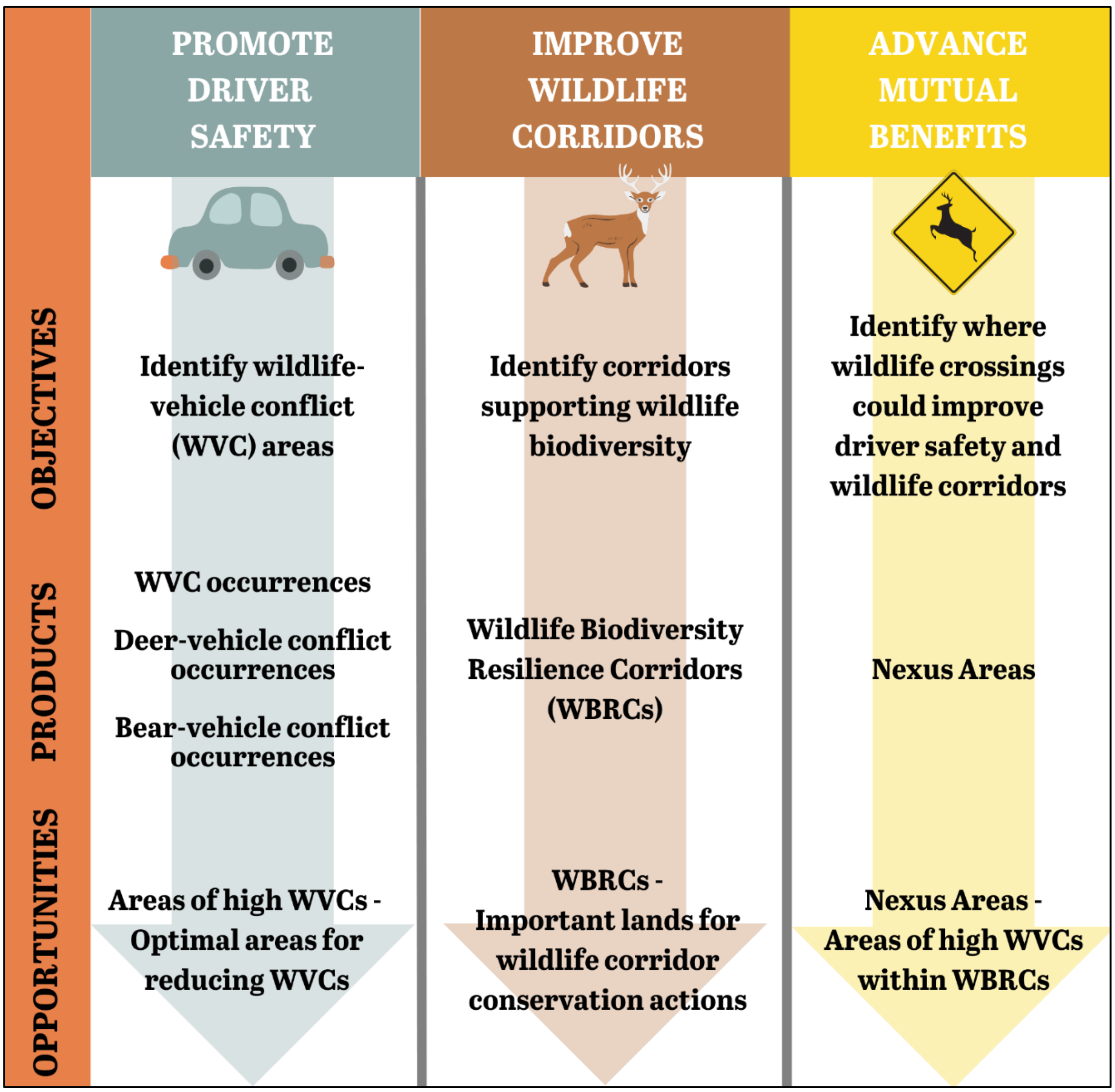
To create this *Wildlife Corridor Action* Plan for the Commonwealth, the Virginia General Assembly enacted § 29.1-578 and § 29.1-579 to establish a collaborative leadership team comprised of the Virginia Department of Wildlife Resources, the Virginia Department of Transportation, the Virginia Department of Conservation and Recreation, and the Virginia Department of Forestry. Pursuant to § 29.1-579, the intentions of this legislation for a *Wildlife Corridor Action Plan* are as follows:

- ***Intent #1***: Identify wildlife habitat corridors comprised of high quality habitats for priority species and ecosystem health using the best available data;
- ***Intent #2***: Identify existing or planned human barriers to wildlife movement along such corridors;
- ***Intent #3***: Identify areas of high risk for wildlife-vehicle conflicts;
- ***Intent #4***: Prioritize and recommend wildlife crossing projects intended to promote driver safety and wildlife habitat connectivity;
- ***Intent #5***: Provide a public portal to host this Plan, data, and maps; and
- ***Intent #6***: Update this Plan every four years.

Based on these intents, the leadership team developed a conceptual framework for this first Plan iteration centered on the following three themes:

- Promote Driver Safety
- Improve Wildlife Corridor Connectivity
- Advance Mutual Benefits

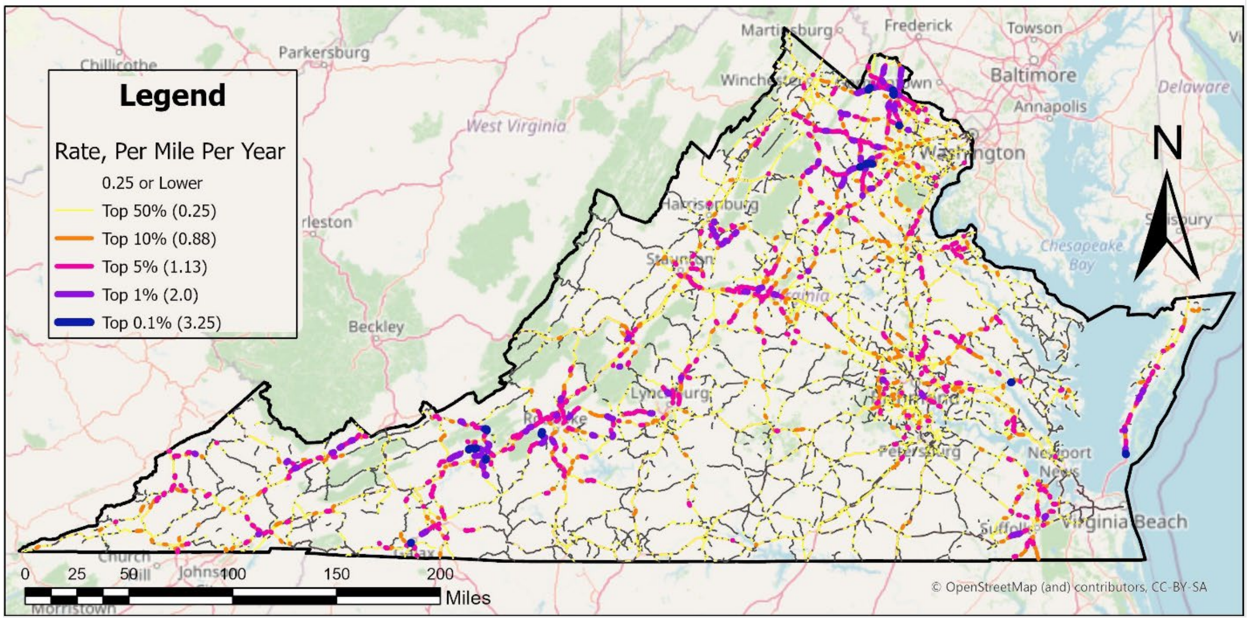
Objectives, products, and opportunities were then designed, developed, and identified, respectively, to align with these themes (see figure below).



Conceptual framework for the Wildlife Corridor Action Plan.

Promoting Driver Safety

To identify road segments experiencing high occurrences of wildlife-vehicle conflicts (see below figure), a geospatial analysis was performed using a subset of data from two databases, Virginia Roads and Virginia Smart Roads. These data collectively offer the most comprehensive statewide data on wildlife-vehicle conflicts that are currently available for Virginia. The data are particularly relevant for collisions with white-tailed deer and black bear, due to how these two species are associated with more costly and injurious collisions for drivers.



Reported wildlife-vehicle occurrence rates per one-mile road segments.

This Plan acknowledges the following about wildlife-vehicle conflicts and driver safety:

- This Plan defines *Areas of High Wildlife-Vehicle Conflicts* as important areas to further evaluate for whether wildlife crash countermeasures are warranted for driver safety.

- Potential wildlife crash countermeasures discussed in this Plan include wildlife crossings (such as enhancing existing underpasses), wildlife advisory messages on Changeable Message Signs, and animal detection driver warning systems.

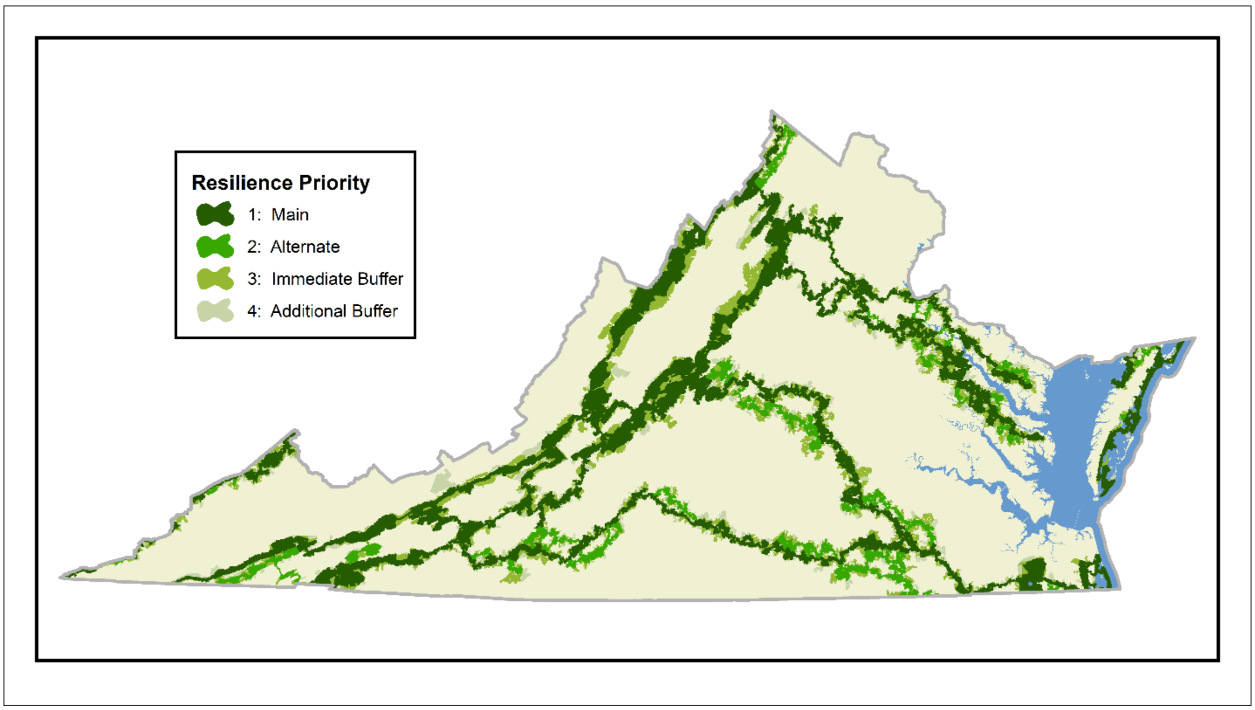
- The Plan encourages, but does not require, consideration of countermeasures early in the transportation planning process for specific types of projects such as the construction of new roads, widening or significant realignment of existing roadways, and bridge and culvert replacements.

- The Plan acknowledges the need for additional monitoring data of wildlife crash countermeasures to assess effectiveness and inform cost-benefit analyses.

- Future updates to the Plan will incorporate a road risk predictability model to identify segments of roads that are at the highest risk of large mammal collisions.

Improving Wildlife Corridors

Leveraging the Commonwealth's ConserveVirginia and Virginia Natural Landscape Assessment conservation planning tools, as well as other data sources, high priority wildlife corridors were identified and designated as the state's *Wildlife Biodiversity Resilience Corridors* (see below figure).



Wildlife Biodiversity Resilience Corridors are comprised of high quality habitats supporting native biodiversity.

The Plan acknowledges the following about improving wildlife corridors:

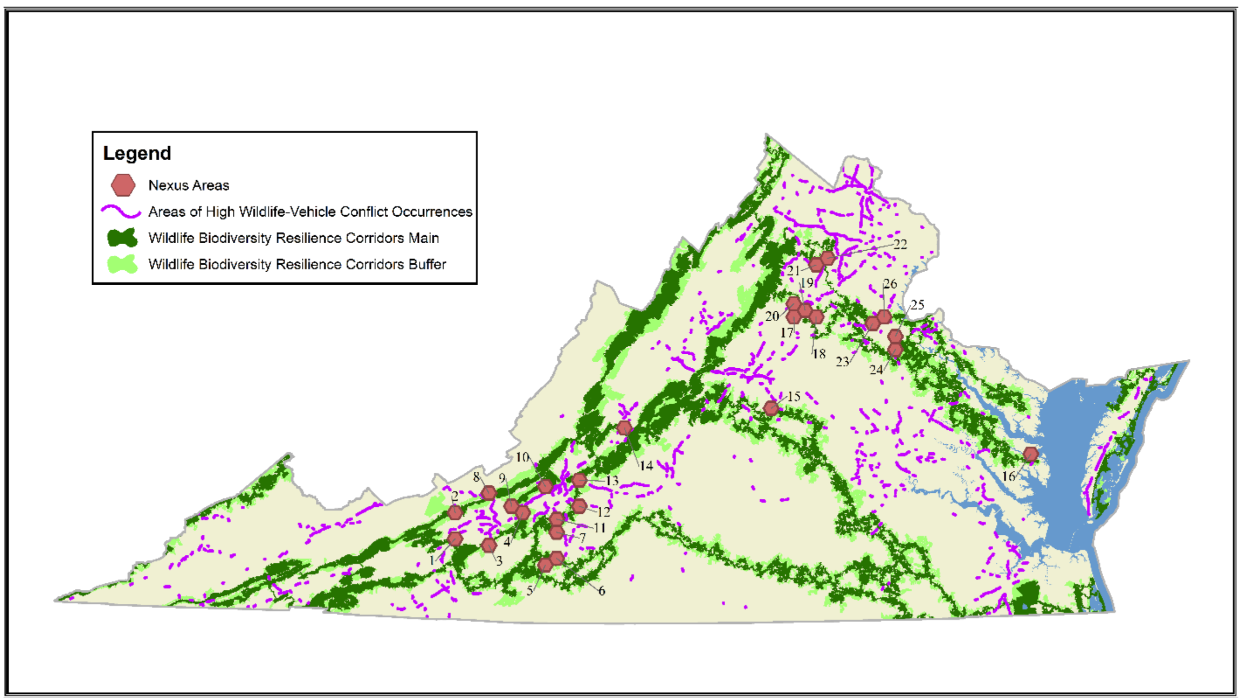
- For the Wildlife Biodiversity Resilience Corridors, further assessment could identify opportunities for conserving, enhancing, and restoring connectivity within these important wildlife corridors, through actions such as land protection strategies, habitat restoration, and wildlife crash countermeasures along roads.

- These Wildlife Biodiversity Resilience Corridors likely do not fully represent all habitat corridors that may be important to specific federally-protected species, state-protected species, and Species of Greatest Conservation Need, as well as for other species of interest.

- Although these statewide wildlife corridors are providing benefits to aquatic resources, a future analysis is needed to identify barriers to aquatic organism passage for identifying aquatic corridor connectivity priorities. Future enhancements to barriers, such as stream culverts, could provide multiple benefits for aquatic organisms, wildlife, and driver safety.

Advancing Mutual Benefits

By spatially overlaying the Areas of High Wildlife-Vehicle Conflicts and the Wildlife Biodiversity Resilience Corridors, 26 *Nexus Areas* were identified (see figure below); these Nexus Areas are coarse scale (25 square-mile areas), and, importantly, they represent opportunities where wildlife crash countermeasures could provide both driver safety and wildlife corridor conservation benefits.



Nexus Areas may be opportunities where wildlife crossing enhancements could improve both driver safety and wildlife corridors.

The Plan acknowledges the following about advancing mutual benefits in relation to these Nexus Areas:

- The Nexus Areas may be particularly important opportunities for seeking competitive federal grant funds, such as under the Wildlife Crossings Pilot Program of the Infrastructure Investment and Jobs Act, which prioritizes proposed projects that will both reduce wildlife-vehicle collisions and improve wildlife corridors.

- Site-specific assessments within the Nexus Areas are required to target the specific road sites that are problematic. Additional field data collection (such as wildlife camera or movement studies, collection of route-specific police report or carcass removal data, or an inventory of existing culverts and bridges) will be required to determine if wildlife crash countermeasures are warranted. Feasibility studies then may be required to assess the practicality for implementing countermeasures such as wildlife crossings.

- Due to the likelihood of limited funding opportunities, a process needs to be developed to prioritize countermeasure projects.

- Given that updating this Plan will be an iterative process as new data and information become available, these Nexus Areas could be refined over time. Additional road sites may also be identified as important opportunities for wildlife crossing enhancements.

Recommendations for Future Actions

To realize a vision of safer roads for wildlife and for people, the *Wildlife Corridor Action Plan* leadership team recommends the following 15 actions to refine and implement this Plan, organized by the intentions of the legislation:

Intent #1: **Identify Wildlife Corridors**

- ❖ Identify at-risk terrestrial and aquatic species and other species of interest not sufficiently addressed by the Wildlife Biodiversity Resilience Corridors.

- ❖ Identify important habitat corridors for these at-risk terrestrial and aquatic species and other species of interest.

Intent #2: **Identify Human Barriers to Wildlife Movement**

- ❖ For aquatic corridor connectivity, conduct analyses to identify road-associated infrastructure and other types of human barriers impeding aquatic organism passage.

- For the Wildlife Biodiversity Resilience Corridors, identify and analyze non-road barriers (e.g., land uses) impacting corridor connectivity.

Intent #3: **Identify Wildlife-Vehicle Conflict Areas**

- Improve and standardize road data collection methods for wildlife-vehicle conflicts and wildlife carcasses.
- For at-risk species and other species of interest, identify wildlife crossing concern areas.
- Develop predictive models to identify site-specific road segments at high risk of deer- and bear-vehicle collisions.

Intent #4: **Prioritize Wildlife Crossing Projects**

- Develop step-down or companion plans, tiering off this Plan, to fully address the habitat corridor and wildlife crossing needs for at-risk species and other species of interest.
- For Areas of High Wildlife-Vehicle Conflict Occurrences, further evaluation is required to identify specific sites where wildlife crossing enhancement projects are warranted and will be feasible.
- For Wildlife Biodiversity Resilience Corridors, evaluate further to identify specific areas that are priorities for land protection, habitat restoration, and/or wildlife crossings to support wildlife corridor connectivity.
- For Nexus Areas, develop a process on how to prioritize wildlife crossing enhancement projects for limited funding opportunities.
- Develop cost-benefit analyses and valuing of wildlife crossings.
- Develop a framework for regional-level and local-level analyses and where efforts to establish targeted partnerships should be focused to identify project opportunities.

Intent #5: **Provide a Public Data Portal**

- To support planning at multiple spatial scales (e.g., state, regional, and local), develop a geospatial viewer application that is inclusive of relevant planning data that are spatially scalable.

Intent #6: **Update Plan Every Four Years**

- Establish state interagency and external coordination to ensure progress on updating and implementing this Plan.

This first Plan iteration offers conservation and transportation planners a foundation for how to jointly prioritize wildlife corridor conservation efforts with wildlife-vehicle conflict reduction measures. Although data gaps and challenges remain, the Commonwealth of Virginia now has established a strong basis to strategically direct state and federal resources for the mutually compatible benefits of promoting driver safety and improving wildlife corridor connectivity.

Visit the website for the Virginia Wildlife Corridor Action Plan

https://dwr.virginia.gov/wildlife/corridors/

Acknowledgments

The leadership of the Virginia Safe Wildlife Corridors Collaborative, Senator David Marsden, and Delegate David Bulova supported Senate Bill 1004 / House Bill 1695, enacted in 2020 (§ 29.1-578 and § 29.1-579), which directed the creation of this *Wildlife Corridor Action Plan*.

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The Virginia Tech Transportation Institute conducted extensive analyses of statewide wildlife-vehicle conflict data in support of Chapter 3 *Wildlife-Vehicle Conflict in Virginia*. The Virginia Safe Wildlife Corridors Collaborative (administered by Wild Virginia), Virginia Transportation Research Council (the research section of VDOT), and Fort Belvoir graciously provided inputs for Appendix D *Wildlife Crossing Case Studies in Virginia*.

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List of Abbreviations

Aquatic Organism Passage (AOP)
Biodiversity Action Plan (BAP)
Changeable Message Sign (CMS)
Department of Motor Vehicles (DMV)
Federal Highway Administration (FHWA)
Great Dismal Swamp National Wildlife Refuge (GDSNWR)
Highway Maintenance Management System (HMMS)
Infrastructure Investment and Jobs Act (IIJA)
Innovation and Technology Transportation Fund (ITTF)
Natural Land Network (NLN)
Optimized Hot Spot Analysis (OHSA)
Species of Greatest Conservation Need (SGCN)
Subject Matter Expert (SME)
Virginia Department of Conservation and Recreation (VDCR)
Virginia Department of Forestry (VDOF)
Virginia Department of Transportation (VDOT)
Virginia Department of Wildlife Resources (VDWR)
Virginia Natural Landscape Assessment (VaNLA)
Virginia Transportation Research Council (VTRC)
Wildlife Biodiversity Resilience Corridor (WBRC)
Wildlife Corridor Action Plan (WCAP)
Wildlife Crossing Concern Area (WCCA)
Wildlife-Vehicle Conflict (WVC)

Definitions

Aquatic organism passage – The ability of fish and other aquatic organisms to migrate and swim freely upstream and downstream in a water body through or beneath human infrastructure such as culverts, bridges, diversions, dams, etc.

Barrier effect – The combined effect of traffic mortality, physical barriers, and avoidance, which together reduce the likelihood and success of wildlife being able to cross a roadway.

Biodiversity – The biological variety of life on Earth, including all species, their genetic variation, and their assemblages in communities and ecosystems, as well as the processes linking ecosystems and species.

Corridor – Physical linkage or connection between habitat patches within a landscape.

Connectivity – The state of structural landscape features being connected, enabling access between places via a continuous route of travel.

Deer-vehicle collision – A wildlife-vehicle conflict that involves a deer and results in a collision.

Ecoregion – An ecologically and geographically defined region in which biodiversity tends to be distinct from other regions.

Habitat – The type of site (vegetation, soils, etc.) where an organism or population naturally occurs—including a mosaic of components required for the survival of a species.

Habitat fragmentation – Subdivision and reduction of the habitat area available to a given species caused directly by habitat loss (e.g., land use conversion) or indirectly by habitat isolation (e.g., barriers preventing movement between habitat patches).

Habitat patch – A discrete area with a definite shape and spatial configuration used by a species for breeding, foraging, cover, or other purpose.

Human-caused barrier – A road, culvert, fence, wall, commercial or residential development, or other human-made structure that has the potential to affect the natural movement of wildlife across a landscape.

Nexus Area – An area within Virginia where high wildlife-vehicle conflicts (as described within Chapter 2 *Wildlife-Vehicle Conflict*) occurs within or adjacent to a Wildlife Biodiversity Resilience Corridor (as described within Chapter 3 *Wildlife Biodiversity Resilience Corridors*).

Node – A small piece of habitat that acts as a stepping stone and greatly facilitates movement of species across habitat patches.

Resilience – The capacity of ecosystems to retain their integrity, functions, and services to continue supporting biodiversity as land use and environmental conditions change over time.

Representativity – The measure of whether a given area contains habitat / biotope types, species assemblages, ecological processes or other natural features that are characteristic of the larger region.

Wildlife – All species of wild animals, wild birds, and freshwater fish in the public waters of the Commonwealth of Virginia (Code of Virginia § 29.1-100).

Wildlife Biodiversity Resilience Corridor – A wildlife corridor designed from the landscape-scale perspective for the movement of native species and to allow species temporal distribution shifts across the Commonwealth as the climate changes and the surrounding landscape becomes more developed. Wildlife Biodiversity Resilience Corridors are a product of this Plan.

Wildlife corridor – An area connecting fragmented wildlife habitats separated by human activities or infrastructure.

Wildlife crash countermeasure – A measure intended to reduce or eliminate a conflict between wildlife and a vehicle. Three types of countermeasures are: (1) wildlife crossings, including enhancing existing underpasses with fencing and other features; (2) wildlife advisory messages on Changeable Message Signs; and (3) animal detection driver warning systems.

Wildlife crossing – Road infrastructure overpasses or underpasses used by wildlife to cross above or beneath a road.

Wildlife Crossing Concern Area – An area within Virginia identified by Subject Matter Experts (SMEs) as potentially experiencing unacceptable levels of wildlife mortality on roads, based on these experts' observations, which may be causing detrimental population impacts to specific wildlife species or taxonomic groups. These areas need further study to first determine the wildlife mortality level and, if found to be unacceptable, to then determine whether wildlife crash countermeasures are warranted. Wildlife Crossing Concern Areas are listed within Appendix D.

Wildlife-vehicle conflict – Any adverse incident that involves a moving vehicle and a wild animal; this may or may not include a wildlife-vehicle collision where the animal and vehicle make physical contact.

Chapter 1
Introduction

"Habitat connectivity, in the form of large cores of intact habitat and corridors connecting them, is critical to ensuring a sustainable future for Virginia."

~ Wild Virginia

The interest in wildlife corridors management has been growing nationally as conservation practitioners continue to evolve strategies to abate the detrimental effects of habitat loss and habitat fragmentation on species. The premise of wildlife corridors is that they connect fragmented habitat patches separated by human activities, land uses, and infrastructure, and this habitat connectivity is vital to the long-term sustainability of wildlife biodiversity. Many wildlife species need to move across the landscape to locate food, optimize breeding opportunities, and seek different habitats for seasonal shelter needs.

Roads are human-built infrastructure that impact habitats used by many wildlife species. Initially, road construction causes habitat loss, degradation, and fragmentation. Vehicle collisions with wildlife exacerbate the habitat fragmentation effects of roads for some species through direct wildlife mortality and impeding genetic exchange within a wildlife population.

Wildlife-Vehicle Conflict
Any adverse incident that involves a moving vehicle and a wild animal; this may or may not include a wildlife-vehicle collision where the animal and vehicle make physical contact.

Wildlife Crash Countermeasure
A measure intended to reduce or eliminate a conflict between wildlife and a vehicle.

Wildlife Crossing
A type of wildlife crash countermeasure that is a road overpass or underpass used by wildlife to cross above or beneath a road.

These collisions and other forms of wildlife-vehicle conflicts (WVC) pose a well-documented risk to the safety of drivers and can cause significant vehicular property damage. Though human injuries and fatalities resulting from actual collisions between motorists and wildlife are considered infrequent, they do occur and can include crashes from avoidance maneuvers. Virginia is one of the higher-risk states in the country when it comes to collisions involving white-tailed deer (*Odocoileus virginianus*), the most common wildlife species identified during WVC events in the Commonwealth. Virginia ranks 15th in the country in wildlife-vehicle collisions, experiencing 10,000 serious human injuries and 200 fatalities due to wildlife-vehicle collisions every year (State Farm Mutual Automobile Insurance Company 2022; Wild Virginia 2021). The number of deer-vehicle collisions in Virginia increased 25% from 2005 to 2017, and more than 60,000 have occurred per year since 2015, costing approximately $533 million in damages annually (Donaldson and Elliott 2021). These numbers are expected to grow in the future as land development and road infrastructure footprints continue to expand across Virginia.

To make roads safer for drivers and wildlife, wildlife crash countermeasures, in particular wildlife crossings, are a critical strategy that is being integrated into road transportation design and modification projects with greater frequencies across the nation. Benefits of wildlife crash countermeasures are:

- *Improved Driver Safety*: Countermeasures are effective at promoting driver safety by reducing the rate of WVC events.
- *Reduced WVC Costs*: The average cost of a deer-vehicle collision in Virginia is $41,000; an elk crash is estimated at $80,000.
- *Safe Wildlife Passage*: Wildlife crash countermeasures, such as wildlife crossings, are effective at reducing wildlife mortality on roads and supporting wildlife habitat connectivity (Ament et al. 2021).
- *Biodiversity Resilience*: Protecting wildlife corridors positions the Commonwealth's biodiversity to be more resilient from key threats, in particular changing climates.
- *Supporting Virginia's Economy*: According to Wild Virginia (2021), "The outdoor recreation industry generates $1.2 billion in state and local tax revenue in Virginia each year, driven in part by activities dependent on healthy wildlife populations, such as fishing, birdwatching, and hunting. Enhancing habitat for native wildlife through wildlife corridors will help sustain the state's natural resources that are central to the

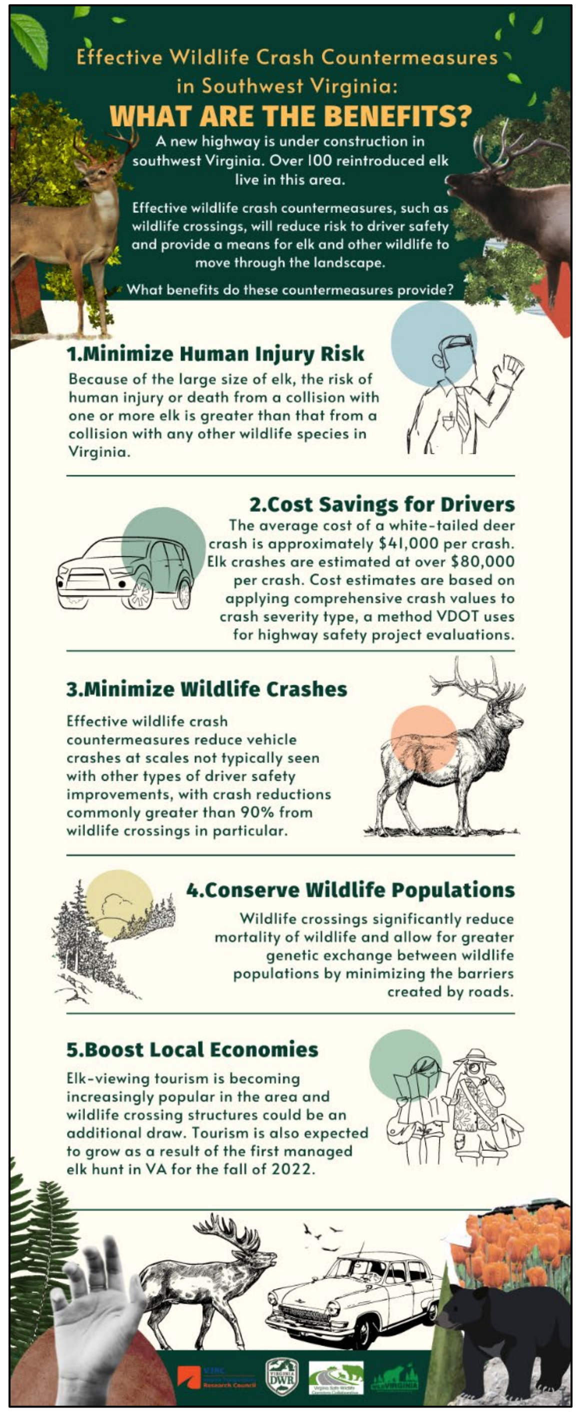

Figure 1-1. Wildlife crash countermeasure benefits for a transportation project in Southwest Virginia. (C. Hayes/Wild Virginia)

197,000 jobs and $6.5 billion in wage and salaries generated by outdoor recreation in Virginia."

Virginia Wildlife Corridor Action Plan

Virginia is one of the first states in the eastern U.S. to create a *Wildlife Corridor Action Plan* (WCAP or Plan) with a clear emphasis on reducing wildlife-vehicle conflict to promote driver safety and protecting vital wildlife corridors. Along with seven states across the U.S. that have passed wildlife corridor protection bills associated with roadways in recent years (New Hampshire, New Mexico, Oregon, Washington, Wyoming, Utah, and Nevada), the Virginia General Assembly enacted § 29.1-578 and § 29.1-579 of the Code of Virginia (see Appendix A) in 2020 to establish a collaborative leadership team comprised of the Virginia Department of Wildlife Resources (VDWR), the Virginia Department of Transportation (VDOT), and the Virginia Department of Conservation and Recreation (VDCR) to create this Plan. In 2021, § 29.1-579 was amended to add the Virginia Department of Forestry (VDOF) to the collaboration and provide additional guidance on implementation of the Plan once it was completed. In addition, § 29.1-579 requires for this Plan to be updated every four years.

Pursuant to § 29.1-579, the intentions of this legislation for a *Wildlife Corridor Action Plan* are as follows:

- ***Intent #1:*** Identify wildlife habitat corridors comprised of high quality habitats for priority species (including federally-protected and state-protected species and at-risk species), and ecosystem health using the best available data;

- ***Intent #2:*** Identify existing or planned human barriers to wildlife movement along such corridors;

- ***Intent #3:*** Identify areas of high risk for WVCs;

- ***Intent #4:*** Prioritize and recommend wildlife crossing projects intended to promote driver safety and wildlife habitat connectivity, with descriptions of projects and wildlife crossing infrastructures or mitigation techniques recommended by this Plan;

- ***Intent #5:*** Provide a public portal to host this Plan, data, and maps; and

- ***Intent #6:*** Update Plan every four years.

Based on these intents, the leadership team developed a conceptual framework for this first Plan iteration centered on the following three themes: promote driver safety; improve wildlife corridor connectivity; and advance mutual benefits (Figure 1-2). Objectives, products, and opportunities were then designed, developed, and identified, respectively, to align with these themes (see Table 1-1).

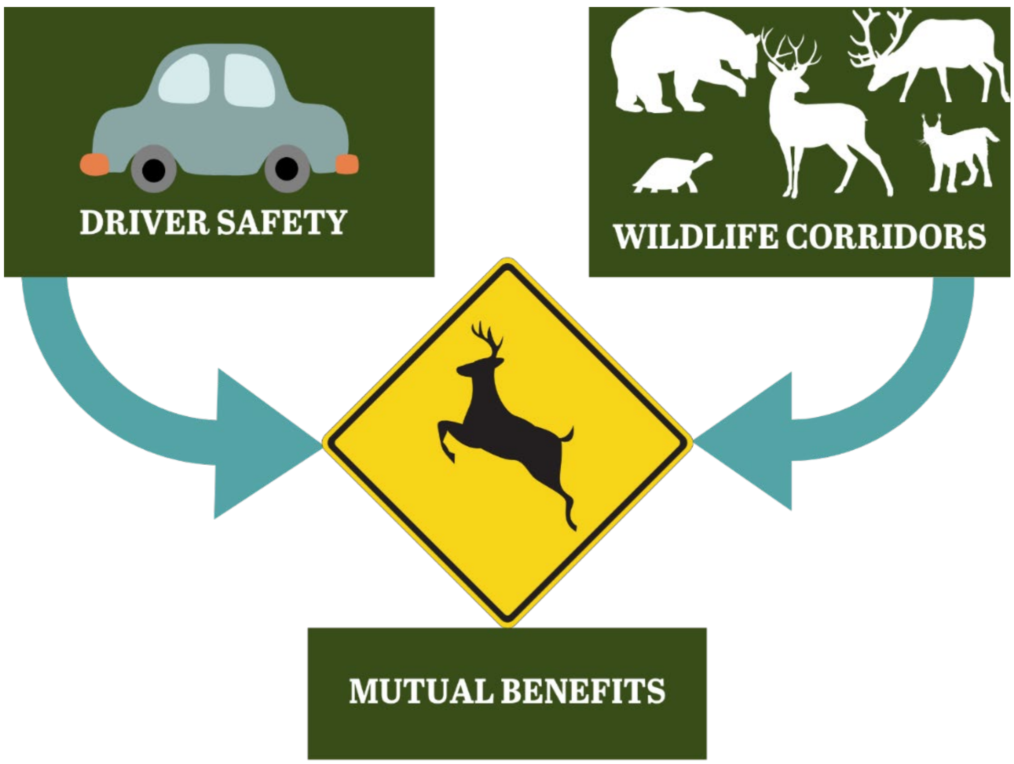

Figure 1-2. Three themes guiding the development of the Wildlife Corridor Action Plan.

For this first Plan iteration, Table 1-2 outlines the approach for how the leadership team addressed the legislative intentions, including when an intent that could not be fully addressed. For example, it was not feasible to develop a prioritized list of wildlife crossing enhancement projects, per Intent #4, due to data limitations and gaps; instead, opportunity areas were identified for further evaluation. Table 1-2 also includes the data sources, data gaps and plan limitations, and the recommended actions that can be pursued to update this Plan for future iterations; these components are further discussed in subsequent chapters.

Table 1-1. Conceptual framework for the Wildlife Corridor Action Plan.

Theme	Objective	Products	Opportunities
Promote Driver Safety	Support driver safety by identifying wildlife-vehicle conflict (WVC) areas	▪ WVC occurrences ▪ Deer-vehicle conflict occurrences ▪ Bear-vehicle conflict occurrences	*Areas of High WVC Occurrences:* Optimal areas for reducing wildlife-vehicle conflicts
Improve Wildlife Corridors	Identify wildlife corridors supporting the long-term resiliency of wildlife biodiversity	▪ Wildlife Biodiversity Resilience Corridors	*Wildlife Biodiversity Resilience Corridors:* Important lands for wildlife corridor conservation actions
Advance Mutual Benefits	Identify where wildlife crossings could improve both driver safety and wildlife corridor connectivity	▪ Nexus Areas[1]	*Nexus Areas:* Optimal areas to improve both driver safety and wildlife corridor connectivity

[1] Areas of High WVC Occurrences that occur within Wildlife Biodiversity Resilience Corridors.

Table 1-2. Detailed overview of how the Wildlife Corridor Action Plan addresses the legislative intentions (§ 29.1-579).[1]

Legislative Intent	Theme	Plan Focus	Approach	Primary Data Sources	Plan Limitations / Data Gaps	Recommended Future Actions
Intent #1 **Identify Wildlife Corridors**	**Improve Wildlife Corridors**	Wildlife Biodiversity Resilience Corridors (WBRC) were selected as the corridor type to design, to benefit the wildlife biodiversity of Virginia.	WBRCs were designed by identifying connected patches of natural lands that have high quality habitat, ecological integrity, support biodiversity (including priority and at-risk species), span across Virginia's ecoregions, and will support climate resiliency for wildlife species.	Virginia Natural Landscape Assessment ConserveVirginia See Chapter 3 for more sources	Important habitat corridors for regional/local planning needs, at-risk terrestrial and aquatic species (federally-protected species, state-protected species, and Species of Greatest Conservation Need [SGCN]), and other species of interest (e.g., elk, amphibians, and reptiles) were likely not fully represented within the WBRCs.	1.1. Identify at-risk terrestrial and aquatic species and other species of interest whose corridor needs are not sufficiently addressed by the WBRCs. 1.2. Identify important habitat corridors for the at-risk terrestrial and aquatic species and other species of interest. *Also see Action #5.1 below for supporting regional and local planning needs for wildlife corridors.*
Intent #2 **Identify Human Barriers to Wildlife Movement**	**Improve Wildlife Corridors** **Promote Driver Safety**	Roads were the exclusive focus to analyze as a human barrier to terrestrial wildlife movement.	Roadways were selected for wildlife-vehicle conflict (WVC) analyses by using the Functional Classification System to focus on Interstates, U.S. Highways, Other Freeways and Expressways, Principal and Minor Arterials and Major Collectors. Minor Collectors and Local classifications were omitted. The roadways also were filtered by a minimum speed of 45 miles per hour.	Virginia Roads layer Virginia Roads Centerlines and base maps	Road and other barriers to aquatic organism passage (AOP), such as culverts and dams, were not addressed. Other land uses causing barriers for wildlife corridor connectivity (e.g., urban and suburban development, intensive agriculture) were not addressed. The legislation also identifies electrical lines and pipelines as potential barriers; however this potential is often best addressed during the siting phase for this infrastructure.	2.1. For aquatic corridor connectivity, conduct AOP analyses to identify road-associated infrastructure and other types of human barriers impeding corridor connectivity. 2.2. For the WBRCs, identify and analyze non-road human barriers (e.g., land uses) impacting corridor connectivity.
Intent #3 **Identify Wildlife-Vehicle Conflict Areas**	**Promote Driver Safety**	Virginia Roads and Virginia Smart Roads databases (collision data compiled by the Virginia State Police) were identified as the best available data for WVC analyses.	Wildlife-vehicle conflict data (61,688 collisions) from 2013-2020 were analyzed. WVC occurrence rates (per mile per year) were calculated and visualized. Road segments experiencing the highest WVC occurrence rates were identified. Due to their large body sizes and population numbers, deer and bear likely result in higher risks to driver safety, as compared with smaller wildlife species. Deer-vehicle conflicts comprised 75% of the collision data. Bear-vehicle conflicts comprised approximately 2.3% of the collision data.	Virginia Roads Virginia Smart Roads	The police-reported WVC data represent only a portion of actual WVCs. Wildlife crash and carcass removal data collection standards lack standardization in the state and nationally. Insufficient data were available to assess WVC impacts for species other than deer and bear.	3.1. Improve and standardize road data collection methods for WVCs and wildlife carcasses. 3.2. Develop predictive models to identify site-specific road segments at higher risk of deer- and bear-vehicle collisions. 3.3. For the at-risk species and other species of interest identified in Action #1.1 above, identify wildlife crossing concern areas.
Intent #4 **Prioritize Wildlife Crossing Projects**	**Promote Driver Safety** **Improve Wildlife Corridor**	A prioritized list of wildlife crossing enhancement projects was **not feasible** in this first Plan iteration, due to data limitations and	Three types of opportunity areas were identified for evaluating whether future wildlife crossing enhancements (or other conservation measures) are warranted and feasible. These opportunity areas include the following: ▪ *Areas of High WVC Occurrences*—Optimizes a focus	Road segments with high WVC occurrences WBRCs	Site-specific data were not available to identify specific sites where wildlife crossing projects are warranted and will be feasible. Cost-benefit analyses and valuing of wildlife crossings are needed to	4.1. Areas of High WVC Occurrences: Further evaluation is required to identify specific sites where wildlife crossing enhancement projects are warranted and will be feasible. Considerations include the following: ▪ Develop methodology to identify specific road segments where wildlife crossings would be beneficial for driver safety. ▪ Develop a process to prioritize potential crossing projects from

Legislative Intent	Theme	Plan Focus	Approach	Primary Data Sources	Plan Limitations / Data Gaps	Recommended Future Actions
Intent #4 continued from prior page	**Advance Mutual Benefits**	gaps. This Plan instead defines opportunity areas that need further evaluation before site-specific projects can be identified and prioritized. It provides a strategic framework that will be the basis for finer-scale analyses and can also inform local jurisdiction planning decisions.	on promoting driver safety ▪ *WBRCs*—Optimizes a focus on wildlife corridor conservation and connectivity ▪ *Nexus Areas*—By overlaying the Areas of High WVC Occurrences onto the WBRCs, 26 Nexus Areas were identified. These Nexus Areas may provide optimal opportunities to both promote driver safety and improve wildlife corridor connectivity.		support effectively prioritizing wildlife crossing opportunities for funding. The Plan does not identify potential wildlife crossing needs for at-risk species and other species of interest. Optimal road sites (i.e., the Nexus Areas where both driver safety and corridors can be improved) for wildlife crossing enhancements may be revised in future Plan iterations as more information and data become available.	a driver safety perspective. 4.2. WBRCs: Further evaluation is required to identify specific areas within WBRCs that are priorities for land protection, habitat restoration, and/or wildlife crossings to support wildlife corridor connectivity. 4.3. Nexus Areas: In addition to the above considerations for Actions #4.1 and #4.2, develop a process on how to prioritize wildlife crossing enhancement projects for limited funding opportunities. 4.4. Step-down or companion plans, tiering from this Plan, will be necessary to fully address the habitat corridor and wildlife crossing needs for at-risk terrestrial wildlife and aquatic species and other species of interest. 4.5. Develop cost-benefit analyses and valuing of wildlife crossings. 4.6. Develop a framework for regional-level and local-level analyses and where efforts to establish targeted partnerships should be focused to identify project opportunities.
Intent #5 **Provide Public Data Portal**	**Supports All**	A website has been provided to host the plan, maps, and data.	Visit the website at: https://dwr.virginia.gov/wildlife/corridors/	n/a	Not all of the data used in this Plan are available for public download at this website. Links to DWR Wildlife Information GIS data and viewable layers of the WBRC data are provided.	5.1. To support planning for wildlife corridor connectivity at multiple spatial scales (e.g., state, regional, and local), develop a user-friendly geospatial viewer application that is inclusive of relevant planning data that are spatially scalable.
Intent #6 **Update Plan Every Four Years**	**Supports All**	Update this WCAP every four years as part of an iterative process. Updated Plans likely will include revisions to the opportunity areas and should include recommended priorities for wildlife crossing enhancement projects.		n/a	For Plan updates and implementation, staff and funding resources need to be identified.	6.1. Establish state interagency and external coordination to ensure progress on updating and implementing this Plan. Initial tasks may include the following: ▪ Identify staff and funding opportunities ▪ Prioritize the Recommended Future Actions ▪ Develop a timeline for which actions can be accomplished before the next Plan update ▪ Identify and establish working groups as needed, including a focus on timing of implementation and coordination with technical and subject matter expert groups

[1] Print this table on 11x17-inch paper. Acronyms used in this table: AOP = aquatic organism passage; SGCN = Species of Greatest Conservation Need; WBRC = Wildlife Biodiversity Resilience Corridor; WVC = wildlife-vehicle conflict

Plan Assumptions

For the development of this Plan, the leadership team defined the following fundamental assumptions:

- *Species Size Matters for Driver Safety in Wildlife-Vehicle Conflicts*
  Large wildlife species are more likely to cause WVCs that threaten driver safety, as compared to smaller species.

- *This Plan's WVC Analysis is Most Relevant for Large Terrestrial Mammals*
  Due to how the available WVC data (as discussed in Chapter 2) provide limited specificity for involved species, the WVC analysis within this Plan is most relevant for large terrestrial mammals, specifically for white-tailed deer and black bear (*Ursus americanus*). Elk (*Cervus canadensis*) are another large terrestrial mammal that can pose a driver safety risk and are relatively new to the modern Virginia landscape. However, this species has a limited distribution within Southwest Virginia, and sufficient data were not available during the development of this Plan to assess elk-vehicle conflict risk. For a new highway project in Southwest Virginia, a separate research study is underway to address the risk of elk-vehicle conflicts for that future highway (see Appendix B *Wildlife Crossing Case Studies*).

- *Wildlife Corridor Needs in Virginia Are Not Similar to Those in the Western U.S.*
  Unlike many state wildlife corridor initiatives in the western U.S., this Plan is not centered on large terrestrial mammals that seasonally range long distances. The historic large mammal species that may have had long-distance seasonal movements were bison (*Bison bison*) and elk; these species were historically extirpated and no other large-bodied mammals in Virginia have long-range movements. Even the recently reestablished elk population in Virginia is not showing inclinations for seasonal long-range movements, but rather move within a general home range, likely based on local food resource availability. Although Virginia may not have large mammals that range long distances, numerous bird, bat, insect, and fish species do migrate over long distances or have seasonal movements. However, these smaller species are assumed to pose a less significant threat to driver safety than large mammals.

- *Biodiversity and Resilience are "Built" into the Wildlife Corridors*
  As Chapter 3 demonstrates, the statewide wildlife corridors presented in this Plan were developed with the intent of identifying coarse-scale corridors comprised of high quality habitats that directly benefit a broad range of the terrestrial biodiversity of Virginia, as well as providing benefits to aquatic resources. In addition, the spatial data analyses driving the corridor identification were designed to promote long-term ecosystem resilience as land use and environmental conditions change over time.

- *This Plan will be Iterative*
  Pursuant to § 29.1-579, the *Wildlife Corridor Action Plan* is an iterative plan that will be updated every four years. This first iteration offers state, regional, and local conservation and transportation planners, across both governmental and non-governmental sectors, a foundation for how to jointly prioritize wildlife corridor conservation efforts with WVC reduction measures to advance mutual benefits for both of these critical goals. Importantly, components of this Plan (specifically, spatial data products developed for Chapter 2 and Chapter 3) can also be utilized separately from one another to support an organization's planning efforts for habitat corridor connectivity and/or transportation safety within Virginia. Although data gaps and challenges remain, this Plan offers a strong basis for strategically directing state resources toward protecting wildlife corridors and helping to keep drivers safe.

Plan Structure

The content of this Plan is structured as follows:

- Chapter 2 *Wildlife-Vehicle Conflicts* – This chapter discusses the causes and impacts of WVCs, presents statewide WVC analyses (including areas of high WVC rates), and describes potential solutions on how to improve driver safety through wildlife crash countermeasures.

- Chapter 3 *Wildlife Biodiversity Resilience Corridors* – This chapter describes the methodology used to identify important, coarse-scale wildlife corridors in Virginia.

- Chapter 4 *Opportunities for Further Evaluation* – This chapter recommends opportunity areas across Virginia for further evaluation based on three themes (Promote Driver Safety; Improve Wildlife Corridors; Advance Mutual Benefits), depending on what the user of the Plan is trying to accomplish. It also provides a list of potential federal funding sources for wildlife corridor conservation and wildlife crossings.

- Chapter 5 *Plan Recommendations* – The final chapter details limitations and data gaps for this Plan and recommends future actions for refining this Plan and supporting the Plan's transition into implementation actions.

- Appendices – The appendices include the WCAP legislation, additional details regarding the Virginia Natural Landscape Assessment (which was the basis for the wildlife corridors identified for this Plan), a list of wildlife crossing concern areas assembled by expert wildlife biologists, and wildlife crossing case studies in Virginia.

Chapter 2
Wildlife-Vehicle Conflict

Background

Figure 2-1. Black bear with cubs at the edge of a highway. (VDOT)

One of the primary goals of the *Wildlife Corridor Action Plan* is to improve road safety for citizens through reductions in WVCs. Strategies for reducing such collisions, i.e., wildlife crash countermeasures, are primarily addressed through appropriate considerations during transportation project planning and design. The identification of wildlife corridors and other areas of high rates of WVCs is critical to understanding where wildlife crash countermeasures would be most effective.

This chapter will discuss the causes and impacts of WVCs and it will identify potential solutions on how to improve driver safety through wildlife crash countermeasures that reduce the number of collisions between vehicles and large animals, such as white-tailed deer, black bear, and elk. Collisions with large mammals present a safety risk to the traveling public and cause the most damage to roadway infrastructure and vehicles.

In addition to increased roadway safety for the traveling public, implementation of wildlife crash countermeasures, as discussed herein, can provide multiple ecological benefits. For example, wildlife crash countermeasures can connect habitats at a local scale that are currently fragmented by existing infrastructure, and result in greater and more sustainable ecosystem integrity. Countermeasures can also retain or improve intact ecosystems at a landscape scale when developing infrastructure projects at a new location.

Note on Terminology

Various terminology is used in the literature when referring to an incident that involves a moving vehicle and an animal on a roadway. Commonly used terms include animal-vehicle collision, wildlife-vehicle collision, deer-vehicle collision, animal strike, animal-vehicle crash, animal-vehicle encounters, and others. “Conflict” as opposed to “collision” is used herein to include the many animal-related safety incidents that may occur such as how animals on a roadway can result in a vehicle collision with other vehicles or fixed objects. Please reference the Definitions section of this Plan for key terminology used and referenced in this chapter.

Scope of the Wildlife-Vehicle Conflict Problem

Figure 2-2. Deer along a roadway at night. (VTRC 2022)

Research has shown that roads have a negative impact on wildlife, which is obvious to those traveling the vast network of highways in the United States. Motorists across the U.S. risk collisions with wildlife of all types and sizes, resulting in a broad range of consequences for both the motorists and animals. Though human injuries and fatalities resulting from actual collisions between motorists and wildlife are relatively infrequent, they do occur and can include crashes from avoidance maneuvers. More commonly, WVCs result in vehicular damage, which can occur from direct impact and secondary motor vehicle crashes. Other results can include travel delays, unsightly carcasses on the roadway, and even emotional trauma. WVCs frequently require the assistance of law enforcement personnel, emergency services, tow vehicles, and road maintenance crews for potential repairs and carcass removal (FHWA 2022).

Across the U.S., the number of WVCs has risen by 50% over the past 15 years, even while the total number of crashes has remained relatively stable over that time (Fleming 2022). This growing statistic can increase stress on species' populations and impacts a driver's well-being on the roadway. Given that many wildlife-vehicle collisions are not reported to law enforcement or insurers, the Federal Highway Administration (FHWA) estimates between 1 million and 2 million wildlife-vehicle collision incidents occur in the U.S. every year. These collisions result in 26,000 human injuries and 200 human fatalities at an annual cost to Americans of $8 billion dollars (Huijser et al. 2015.)

Virginia is one of the higher-risk states in the country when it comes to collisions involving white-tailed deer. Virginia ranks 15th in the country in wildlife vehicle collisions, according to data from State Farm Insurance (State Farm Mutual Automobile Insurance Company 2022). November is the worst month for collisions, followed by October and December (The Wildlife Center of Virginia, n.d.); these months typically correspond with the mating season for white-tailed deer. Deer-vehicle collisions in Virginia increased 25% from 2005 to 2017, and more than 60,000 have occurred per year since 2015 (Donaldson and Elliott 2021). These numbers are expected to grow as development expands.

Identifying High Risk Wildlife-Vehicle Conflict Areas

The large number of WVCs and the variety of environmental factors influencing wildlife movements and driver decisions characterize WVCs as complex and challenging to predict. However, numerous studies have been conducted to understand the relationships between drivers, animals, and the environment. These studies have identified the following factors as commonly influencing WVC locations and rates: the proximity to forest, topography, road width, seasonal differences, and movement based on mating seasons. Independent of species, traffic volume, the distance to urban areas, and roadway infrastructure are not clearly assignable as influencing or non-influencing factors. Various data sets to use in WVC analyses can include carcass removal by transportation staff and crash data, typically available through the Department of Motor Vehicles (DMV) or state police. Proper data collection and the quality of reliable data sets are integral to fully understanding and effectively addressing WVCs and driver protection.

Figure 2-3. Typical sign to warn drivers of areas of frequent deer crossings. (VTRC)

Factors that Influence Wildlife-Vehicle Conflicts

An important component of driver safety is the effect of traffic on WVCs. Traffic characteristics such as volume, speed, and timing can greatly affect the frequency of WVCs, although the relationships between traffic characteristics and wildlife crossing attempts are nonetheless complex. Additional variables influencing this complex relationship are daily and seasonal patterns in both traffic and in animal movements (Ament et al. 2021).

Wildlife Ecological Impacts from Roads and Traffic

Loss of Habitat
Decrease in Habitat Quality
Barriers to Movement
Road Mortality

Extremely high traffic volumes often serve as barriers to animal movement, while lower volumes may increase rates of WVCs as animals attempt to move across roads during intervals when vehicles are sparse or absent. As traffic volumes increase, roadways can become greater barriers to the movement of wildlife, either directly through WVCs or as a result of animal avoidance of the road and nearby habitat. The volume of traffic that constitutes a complete barrier to wildlife movement varies by species, landscape, and other variables. While the barrier effects increase with the number of vehicles, wildlife crossing structures and fencing can greatly reduce this barrier effect by providing a means of safe passages across highways, helping ensure stable local and regional wildlife populations (Ament et al. 2021). Especially high rates of safe passage are found on road segments containing bridges and large drainage structures such as large pipes and culverts, which allow safe passage of wildlife and high levels of habitat connectivity (Meese et al. 2009).

Ungulates (i.e., hooved animals) such as white-tailed deer tend to be attracted to roads due to the presence of forage along roadsides, medians, and interchange loops. Most large-bodied mammals are more inclined to approach roads and to use crossing structures where desirable vegetation is present, particularly where there is an interface with forested areas that serve as cover from predators. Thus, in wildlife crash countermeasures assessments, the habitat preferences, including sources of both food and cover, must be carefully considered within and along the right-of-way. Roads with sharp curves, undulations in the road surface, and thick roadside vegetation reduce a driver's line of sight, increase driver response time, and may increase the risk of collision should an animal appear on the roadway (Meese et al. 2009). Transportation planners must consider how roadway dynamics such as roadway shape, vegetation in the right-of-way, and nearby habitats all affect WVCs.

Analytical Approach to Identify Wildlife-Vehicle Conflict Areas

To identify the occurrence rate of WVCs along specified Virginia roadways, a geospatial analysis was performed using available statewide datasets—more specifically, deer and bear collisions were analyzed to create a statewide map of WVC occurrences and then areas were classified into WVC occurrence rate categories. Several datasets were sourced and compiled in ArcMap, and later using ArcGIS Pro, to complete the analysis and create a layer of WVC occurrence rates across along roadways.

Data were sourced from two VDOT databases: Virginia Roads and Virginia Smart Roads. These datasets are compiled using police-reported collisions, provided by the Virginia DMV. These reports are created by police at the time of the crash when the damage to the vehicle or other property is estimated to be a minimum of $1,500 (Oleynik and Brich 2017). The dataset used from Virginia Smart Roads (CrashData_Basic) provided data from 2014 to 2020, and the dataset from Virginia Roads (CrashData_2013) provided data from the year 2013. These reports provide relevant data such as the time and date, type of collision, and severity of damage, among other collision information.

The datasets were merged, creating a layer that contained all collisions involving an animal between 2013 to 2020 (61,688 crashes in total). This means that, for every crash in the resultant dataset, a deer or other animal either directly collided with the vehicle(s) or caused a vehicle to collide with another vehicle or object as a result of the driver avoiding or attempting to avoid the animal. Based on the definition of a WVC, all these collision types were included in the analysis.

Additional datasets used included Virginia Road Centerlines, a Virginia border outline, and a base map (OpenStreetMap) to assist in spatially locating the WVCs. The Virginia Roads layer was simplified to only include roads classified as Interstate, U.S. Highway, and Primary State Route (and ultimately filtered by Functional Classification).

Assumptions of the Analysis

While this is the most comprehensive dataset in Virginia for accurately depicting WVC occurrence rates, there are some limitations of the dataset. Although the data are accurate in the reporting of each event, the number of WVCs that are reported by police has been observed to be much lower than actual reported deer collisions. In a study observing carcasses removed along roadways in Virginia, the actual number of deer-vehicle collisions were found to be between four and nine times greater than those reported to the police (Donaldson 2017).

Carcass removal data may serve as an alternative WVC information source that may supplement existing data to assess the number of WVCs more accurately. The Virginia Transportation Research Council (VTRC), the research division of VDOT, is currently conducting a pilot study to test an application for use by interstate contractors to document carcass removals. Police report data should not be discounted as a data source, however, as it provides useful crash severity information that carcass removal data does not.

It also should be noted that, while the focus of this *Wildlife Corridor Action Plan* is on identifying WVC areas, the source data may have included incidents that involved livestock and domestic animals, located outside or inside the vehicle. The police-reported WVC dataset contains crashes in which an animal was involved, but deer is the primary animal specified. Of the main collision types, deer comprise 75% of the data, other animals comprise 6%, and the remaining 19% are undetermined whether each point involves a wild animal; these collisions could have involved domestic pets or livestock. However, it should be assumed that if included in this analysis, domestic animals make up a small percentage of these points and do not heavily influence the final layer. After the analysis of the entire dataset, the data were filtered to produce maps that depict deer and bear WVCs (with the assistance of data provided by Virginia DMV) to provide information on the large wildlife species that are most associated with WVCs resulting in driver safety risk and vehicular damages.

Analysis, Point Density, and Limitations of Use

Using the WVC dataset, a statewide heat map was created (Figure 2-4) that shows point densities of WVC occurrences. Based on this heat map, the multiple observable "hotspots" distributed over the state illustrate that WVCs in Virginia are spatially clustered and are not random.

However, there are some limitations to this type of analysis. While the heat map generally indicates where WVC hotspots are located on a broad scale, it is difficult to evaluate on a smaller, local scale. If users wish to use a similar method for a local-level analysis, it is possible to use the same methodology (with the same aforementioned data sources), but with a smaller geographical boundary, such as a county or city border.

If a user wishes to compare WVC occurrences in a localized area, the results are less informative, as the current layer bases the WVC occurrence rates on the average across the entire state. If the statewide map is used for local-level evaluations this way, it could contribute to overlooking WVC hotspots and opportunities for wildlife crash countermeasures implementation. For example, the statewide map is less useful if county planners wish to find the top 10% WVC hotspots to evaluate opportunities for countermeasures in their county. For local-level analyses, it is recommended to first classify all road segments in the area against each other instead of using the statewide map.

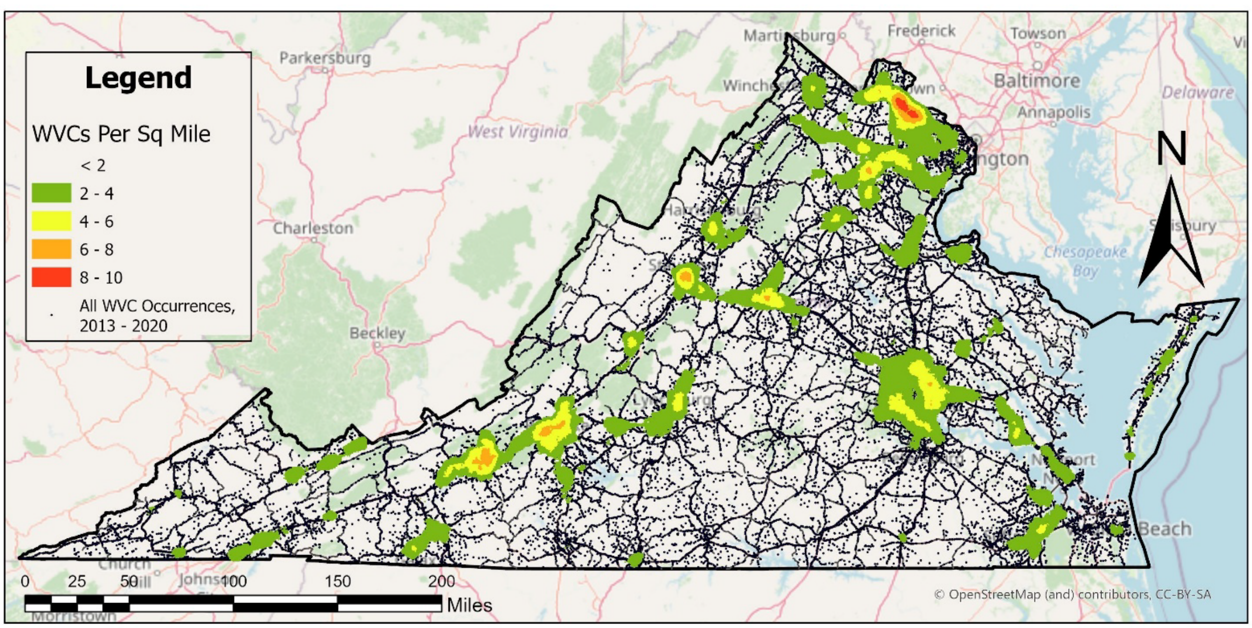

Figure 2-4. Point density map showing reported WVC occurrence density in Virginia for the years 2013 to 2020.

Wildlife-Vehicle Conflict Occurrence Rates by Roadway Segments

Further analyses of WVCs in Virginia included the creation of an interactive, scalable environment, in which the viewer can focus on certain areas and compare them to other areas of the entire state simultaneously. A layer was then created to determine the areas of highest concern across the state based on segments for a focused set of roadways.

The main roadways used in the analysis were determined by using the Functional Classification System of roadways and a minimum speed limit of 45 miles per hour. The Functional Classifications of concern included Interstates, Other Freeways and Expressways, Arterials (both Other Principal and Minor), and Major Collectors. The two remaining classifications, defined as Minor Collectors and Local, were omitted from the analysis. The roadways were also filtered by a minimum speed limit of 45 miles per hour. These road classes were selected to aid with the analysis of road segments and to provide consistency with considerations made during road safety project development. In this layer (Figure 2-5), out of 105,700 total miles of road centerline length in Virginia, nearly 14,300 miles (~13.5%) of roadways were analyzed. The roadways in the resultant layer were then segmented and then combined with the WVC data.

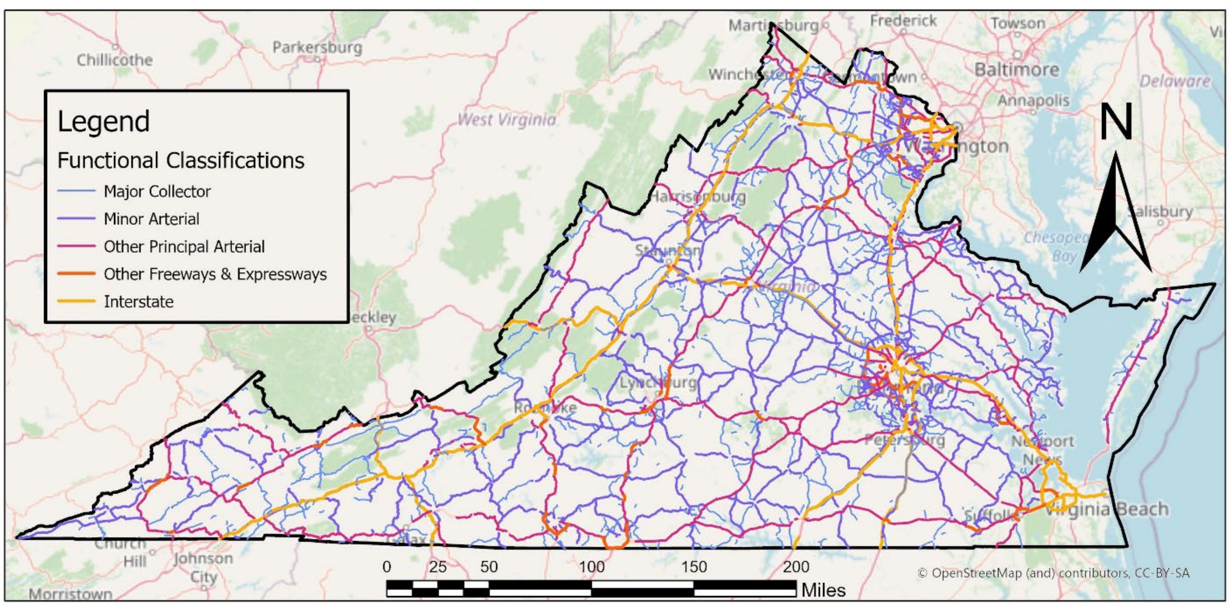

Figure 2-5. Roadways analyzed for segmenting purposes, filtered by the Functional Classifications (listed in legend) and a minimum speed limit of 45 mph.

The roadway classifications were then used to visualize areas by WVC occurrence rates (Figure 2-6) with the top percentage of segments used to visualize occurrence rates. For the WCAP, using the calculated weight value (WVCs per mile per year), the top percentage of segments were used to visualize occurrence rates. The classifications used were the top 0.1%, 1%, 5%, 10%, and 50% of each segment using their weighted value (number of WVCs per mile per year). The values associated with these percentages were calculated using the total of 15,734 road segments and defining the minimum value for each percentage range. The minimum WVC values are parenthetically provided for each percentage classification within Figure 2-6. For example, a weighted value of at least 3.25 WVCs per mile per year was required to be considered in the top 0.1% of all segments (Figure 2-6).

Optimized Hot Spot Analysis

To confirm the analytical findings of the statewide WVC point densities and WVC occurrence rates by road segments, tools such as Optimized Hot Spot Analysis (OHSA) were used to create an objective view of areas where clustering occurs (Figure 2-7). For this analysis, a 350-hectare (approximately 1.35 square miles) cell size was used. This value is based on other studies that identified this as the least conservative area of deer home range estimates (Oden-Plants 2019). Despite the animal-related crashes comprising more than just deer, deer collisions make up over 75% of the data, and therefore conflicts which involve deer are the major influencers of the results. Square cells were created with sides equaling 1,870.83 meters (approx. 1.16 miles) to create the 350-hectare area.

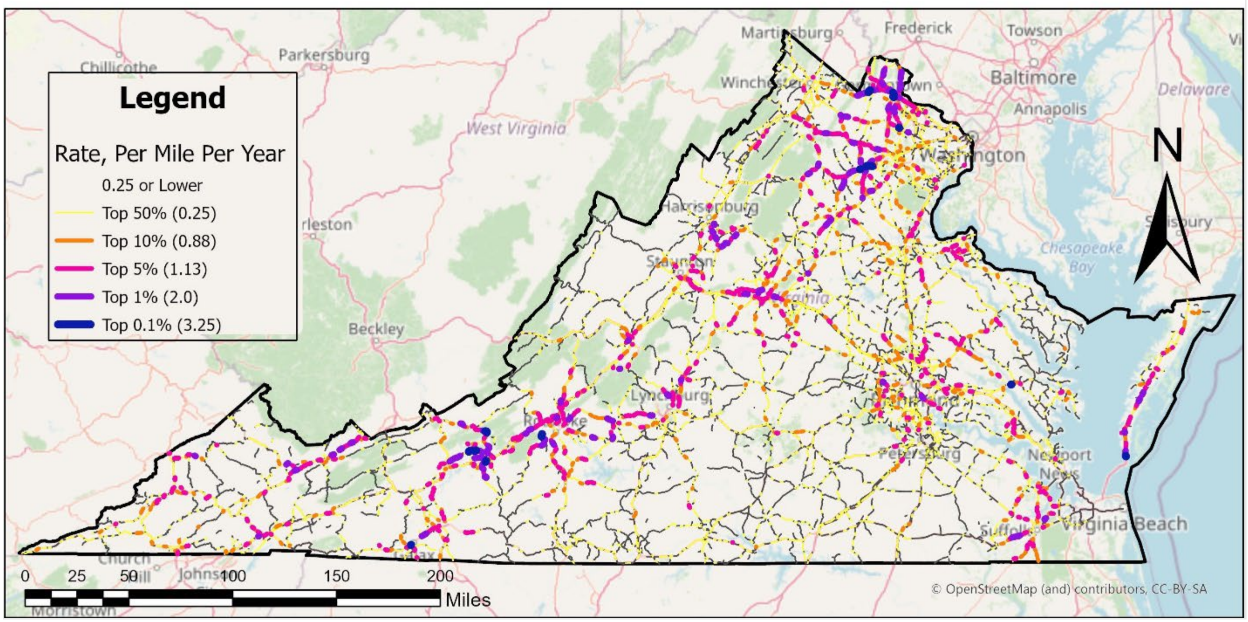

Figure 2-6. Reported WVC occurrence rates per road segment (based on data from 2013 to 2020), classified by top percent categories for all road segments analyzed. The parenthetical value for each classification rate states the minimum number of WVCs per road segment/year.

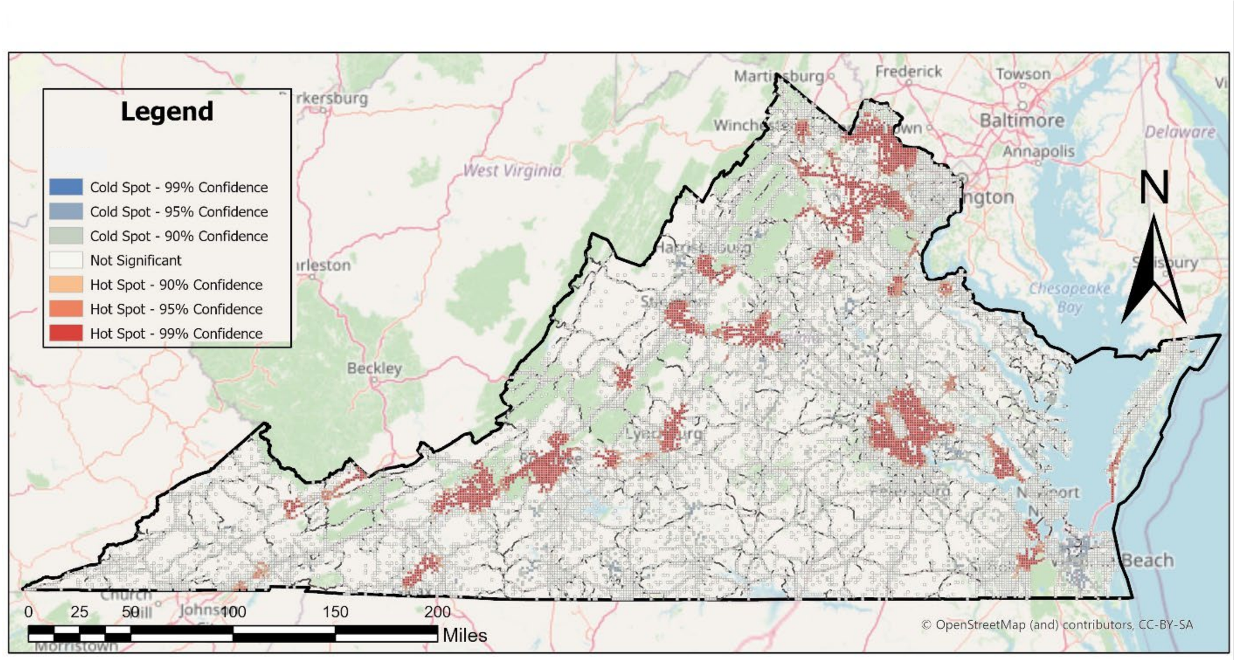

Figure 2-7. Optimized Hot Spot Analysis of WVC occurrences for the years of 2013 to 2020.

When the OHSA layer is overlaid on the WVC point density and road segmenting layers, the OHSA results support the findings from the other two analyses. Areas of high WVC occurrence in both previous analyses (i.e., the analyses of WVC point densities and WVC occurrence rates by road segments) match the areas where the OHSA tool determined a 99% confidence that a hotspot is occurring at that location.

Highway Maintenance Management System Dataset

Other datasets were examined to further understand WVC areas within Virginia, in particular to understand the primary large wildlife species involved in WVCs, i.e., deer and bear. For example, the Highway Maintenance Management System (HMMS) is a database that compiles reports of numerous issues along VDOT-maintained roadways, including reports of carcasses. However, due to this dataset being a crowd-sourced reporting system of animal carcasses, and not a true representation of carcass removal (or the precise location of the carcass), it is not recommended to utilize this dataset as a standalone layer to analyze WVCs in Virginia. However, this database was used in this study as an additional method to identify potential concern areas for WVCs. Figure 2-8 shows the HMMS data for deer and bear carcass observations (reported as per mile per year rates by road segments). For example, a user focusing their review on a certain area could use the statewide OHSA layer and compare it to the HMMS carcass layer to see if a similar carcass removal problem exists in the same area where a collision hotspot is shown.

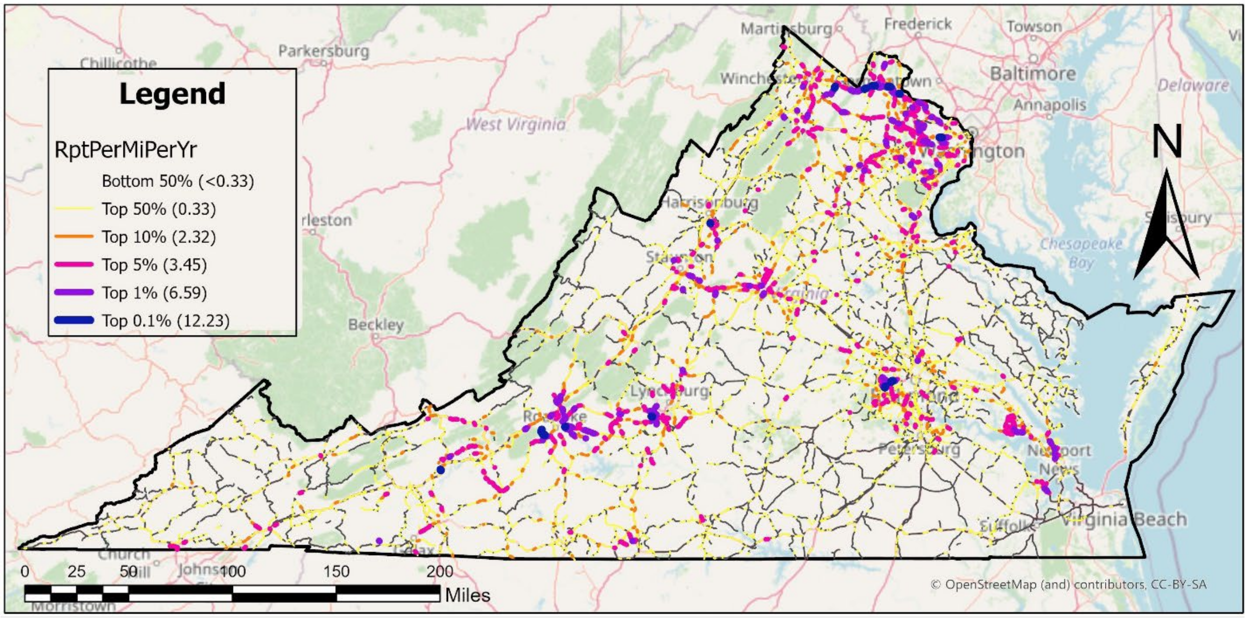

Figure 2-8. HMMS deer and bear carcass reports by road segments, 9/29/2018 to 12/7/2021. RptPerMiPerYr = Reports, Per Mile Per Year.

Filtering Police-Reported Crashes by Animal Type

Since a primary goal of this *Wildlife Corridor Action Plan* is to identify WVC areas of concern, and in particular WVC areas primarily driven by deer and bears, the subsequent sections describe the data filtered by these species. The WVC datasets were joined with the segmented road layer to identify the top percentages of segments across the state.

- *Deer Wildlife-Vehicle Conflicts*

  The primary dataset was filtered by selecting only deer collisions, which comprised 75% of the data records from 2013-2020 (46,296 records in total; Figure 2-9). This only includes crashes in which the deer was the main collision event; by definition, there may be many deer-vehicle conflicts not included in this layer; instances in which a deer is not a contributing factor to the collision, or a secondary event listed within the collision report, are not included in this layer.

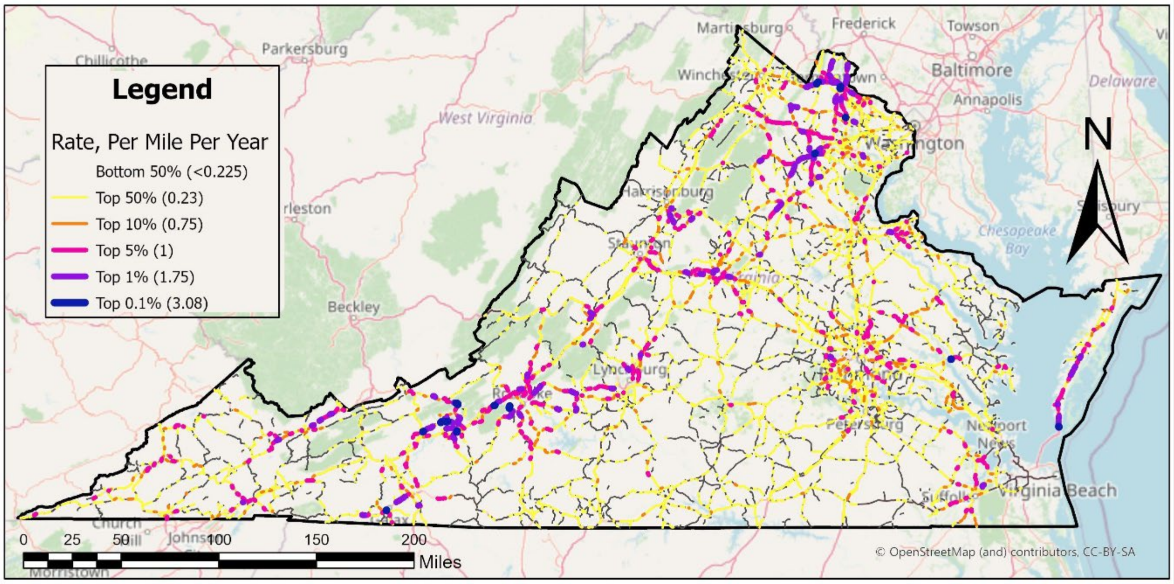

Figure 2-9. Reported deer crash rate segments for the years of 2013 to 2020. Layer created by filtering the police report dataset by deer collisions and joining with generated road segments.

❖ *Bear Wildlife-Vehicle Conflicts*

Bear-related WVCs were identified by selecting for the "bear" keyword in the comments field of the (DMV-compiled) police reports for the years of 2012 to 2021, resulting in 1,421 total occurrence points (Figure 2-10). Of the total 1,132 possible points between the years of 2013 to 2020, only 949 (83.8%) had an associated data point from the primary dataset. Therefore, not all points had an associated animal-related crash. However, because we cannot reference the contents of the comments section, we cannot not rule out the possibility that these other data points were associated with bears. The entire dataset provided by the DMV was therefore used to create and analyze for the creation and analysis of this layer.

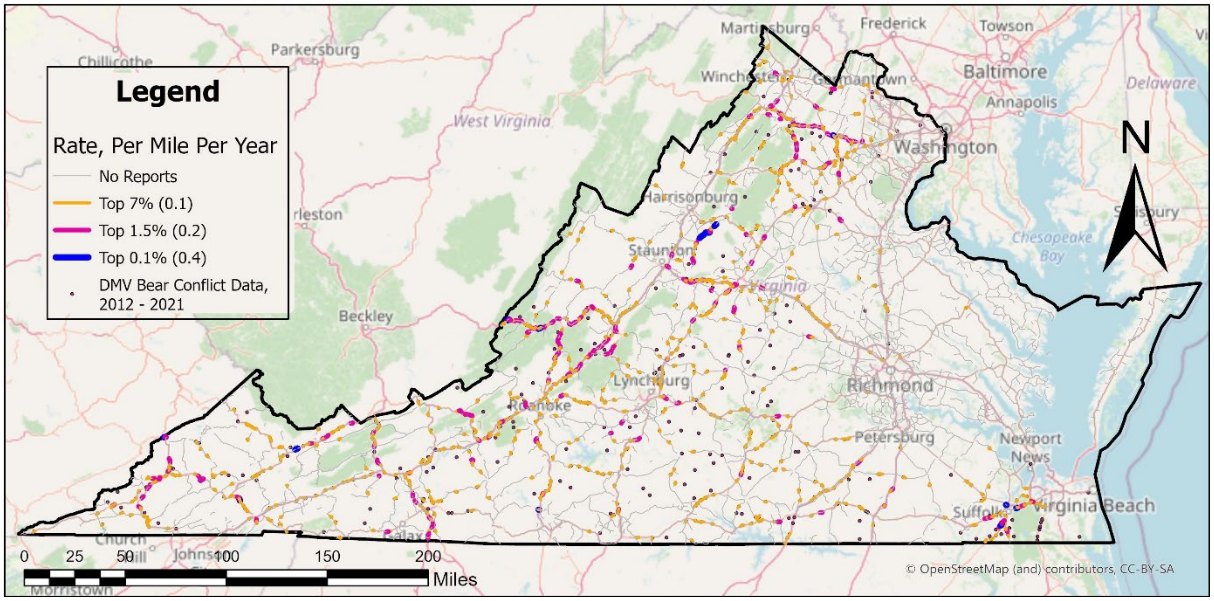

Figure 2-10. Reported bear-related crash segments for the years of 2012 to 2021. Bear-related dataset sourced from DMV joined with generated road segments.

❖ *Other Animal and Remaining Animal-related Crashes*

Since the data can be filtered by crash type and DMV personnel provided data that involved bear in the reports, a standalone layer was created from the remaining (i.e., non-bear and non-deer) crashes in the primary datasets (Figure 2-11). This layer includes collision events that involve other animals, fixed objects, vehicle-to-vehicle collisions, and non-collisions (rollovers/lane departures). Because the deer crashes layer displays only collisions where deer were the main event, it is possible that deer conflicts may remain in this layer, as they could have been a contributing factor to the collision. This layer appears to suggest more randomized occurrences, which could be due to the remainder of collisions likely involving proportionately more domesticated animals than the unfiltered dataset.

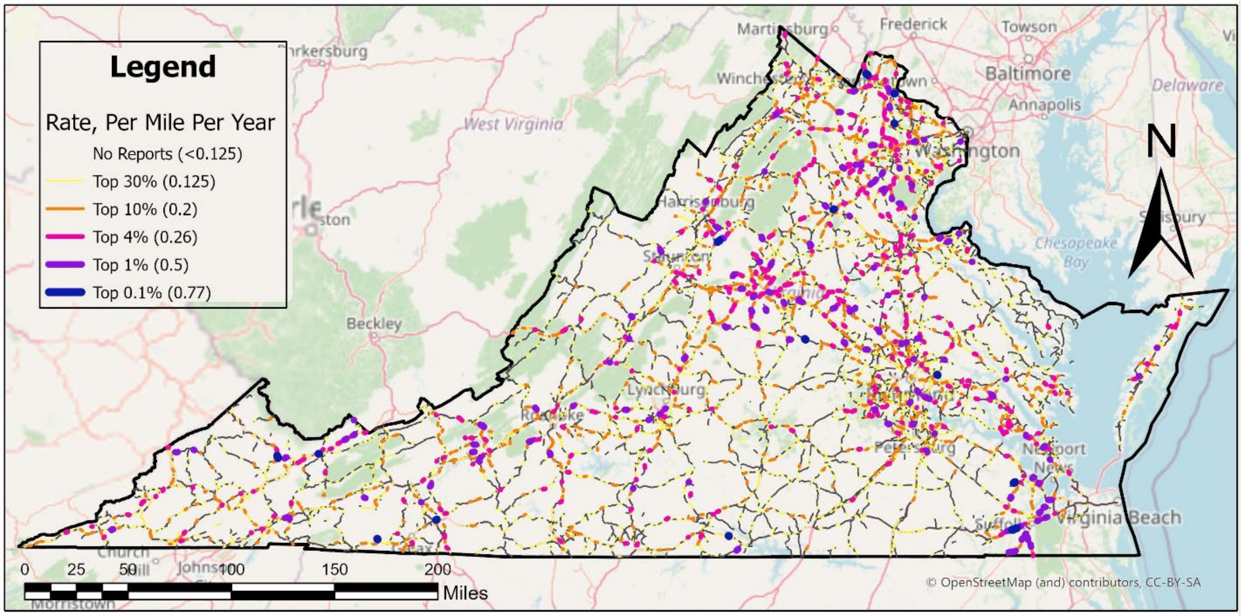

Figure 2-11. Crash rates for other animals (after removing deer collisions and bear-related crashes) for the years of 2013 to 2020. Crash data sourced from DMV joined with generated road segments.

Driver Safety Recommendations

Types of Wildlife Crash Countermeasures to Improve Driver Safety

The VDOT guidance document called the *Large Animal Crash Countermeasures in Virginia: Technical Guidance and Best Management Practices* (Donaldson 2022) provides information on selecting and implementing effective wildlife crash countermeasures for large animal-vehicle collisions. Some of the measures included in the guidelines (wildlife crossings, in particular) can also be effective for smaller wildlife species. The document discusses three primary measures that have been shown to be effective at reducing collisions with large mammals and associated costs from property damage, motorist injury/mortality and animal carcass disposal. These countermeasures include: (1) wildlife crossings, including enhancing existing underpasses with fencing and other features, (2) wildlife advisory messages on Changeable Message Signs (CMS), and (3) animal detection driver warning systems (Donaldson 2022).

❖ *Wildlife Crossings and Enhancing Existing Structures*

Wildlife crossings are overpasses or underpasses used by wildlife to cross above or beneath a roadway. These structures are the most effective method of reducing WVCs while also providing a means for wildlife to access habitat on the other side of a road. Studies have found that a structure's openness ratio, defined as the structure's (height x width)/length is important for medium- and large-bodied mammals. A relatively large openness ratio (i.e., >0.75) may enhance a structure's use by a large animal by allowing sight through a crossing structure as well as providing more natural light conditions (Caltrans 2007). When combined with fencing, which restricts wildlife access to the road and helps guide them toward the crossing, these structures have been found to reduce wildlife collisions by more than 90%. Extending fencing between multiple suitable underpass structures can be expected to result in a significant wildlife crash reduction along the entire length of the fenced road segment (Donaldson and Elliott 2021). Fencing should include jump-outs or escape ramps (Figure 2-12). These features are often constructed of earthen materials but can also consist of shorter sections of specially designed fencing that allows wildlife trapped within the roadway to escape the fenced section.

Figure 2-12. A wildlife jump-out located along I-64 in Virginia. (Donaldson and Elliott 2021)

Existing road segments that have been identified as having high occurrences of wildlife-vehicle collisions can be reviewed for the presence of existing underpasses already suitable for wildlife crossings or existing underpasses that can be enhanced to provide wildlife passage. Many wildlife crossing enhancements can be implemented relatively inexpensively in relation to the overall project budget. Incorporating wildlife passage design elements into maintenance projects, roadway improvement or widening projects, culvert or bridge replacements, or by adding directional wildlife fencing to existing suitable underpass structures may be possible. However, the costs to implement and monitor these types of wildlife passage enhancements should be considered in relation to the overall project budget. Where wildlife crossing construction (or substantial enhancements to existing underpass infrastructure) are considered, the land uses, protection status, and property ownership of the surrounding lands must be evaluated. For example, areas where future development is expected to occur should not be candidate locations for wildlife crossings unless there are protected habitats that will enable wildlife access to the crossing structures (FHWA 2022).

Figure 2-13. Bridge underpass along I-81 north of Buchanan used as a wildlife crossing. (VTRC 2022)

While not specifically safety-related countermeasures, the following measures are other wildlife crossing enhancements to consider for bridge, large culvert, and roadway transportation projects that can provide wildlife passage benefits for multiple species, including for smaller terrestrial and aquatic species:

- Create an underpass trail or passage bench habitat to encourage wildlife passage. Trails should be level, have a minimum width of three feet, and be set above drainage outfalls to prevent washout.
- Reduce riprap/large cobbles that are not conducive to wildlife passage.
- Increase the ease of access to and through bridges and large culverts. This includes contouring or modifying the approaches to an underpass and the slope beneath bridge underpasses.
- Keep structure approaches free of material such as storm debris build-up and thick vegetation.
- Create a flat, natural bottom to arch pipes and concrete box culverts.
- For existing culverts that are not already countersunk, add topsoil or other natural substrate to the culvert floor to improve footing and encourage use by wildlife.
- Create natural or artificial light. For many wildlife species, including deer, more open and well-lit structures will be used more readily than dark, tunnel-like culverts. The addition of grating at the top of the underpass can increase the

natural light inside of a culvert to encourage wildlife use. Artificial light sources can also be installed in dark culverts when grating is not an option.

- For aquatic organism passage, ensure that the inflow and outflow elevations of culverts are designed to allow passage.

❖ *Wildlife Advisory Messages on Changeable Message Signs*

The purpose of CMS, also known as dynamic message signs, is to increase driver safety by calling attention to unexpected conditions. The aim is to increase driver alertness and often to reduce driver speed. Studies suggest that drivers can reduce the chance of a collision with wildlife by reducing speed and remaining alert in areas with abundant wildlife (VTRC 2022). In general, reducing speed has been found to decrease the number of crashes, reducing both the severity of property damage and injuries, and allowing drivers to more successfully correct in avoidance maneuvers. Several studies have found lower numbers of animal crashes in areas with lower speeds (VTRC 2022). While research shows mixed results, some studies, including an evaluation on I-64 in Virginia, have found that seasonal messages alerting drivers to an increased risk of wildlife crashes can be an effective measure of crash reduction. To reduce the likelihood of driver habituation to the messages, the warnings should be displayed only during those times of year and times of day when the risk of large animal crashes are greatest. This information is included in VDOT's Changeable Message Signs policy (IIM-OD-13.03), which states that messages should be displayed in high risk areas only in October through December between the hours of 5:00 PM and 9:00 AM, provided there are no higher priority messages to be displayed (VDOT 2019).

Figure 2-14. Typical changeable message sign to warn drivers of high risk of deer collision. (Johnogroat Journal)

❖ *Animal Detection Driver Warning Systems*

Animal detection systems are designed to sense large animals as they approach the roadway and are intended to warn drivers about their presence. Most animal detection systems contain either above-ground area cover sensors, break-the-beam sensors, or thermal detection devices. These sensor systems work similarly in that the system is activated when an animal's body blocks or reduces the signal. Once detection is verified, a warning system, such as a flashing warning light or a changeable message board that communicates with the detection cable, can alert drivers to be prepared to encounter a large animal, resulting in an increased awareness and reduction in vehicle speed and stopping distance. Buried cable detection systems offer several advantages over above-ground detection technologies when environmental variables such as snowfall or high vegetation blocks a beam, and site-specific characteristics such as topography and road curvature are considered (FHWA 2022).

Although studies show mixed results with regard to their effectiveness, in some areas these systems have been shown to reduce wildlife crashes by more than 90% (FHWA 2022). They seem to be most effective at the ends of fencing associated with wildlife crossings. The VDOT applications of these systems will be considered experimental until more information on their effectiveness can be determined (VTRC 2022).

Planning for Wildlife Crash Countermeasures in Transportation Projects

The transportation project development process offers a critical opportunity for incorporating wildlife crash countermeasures. The need for these countermeasures should be identified early in the planning process to ensure that adequate project funding is available and that any countermeasure designs do not conflict with other project design aspects. Specifically, the inclusion of wildlife crash countermeasures should be identified during the scoping and project initiation phase and then re-evaluated at the preliminary design phase (Figure 2-15).

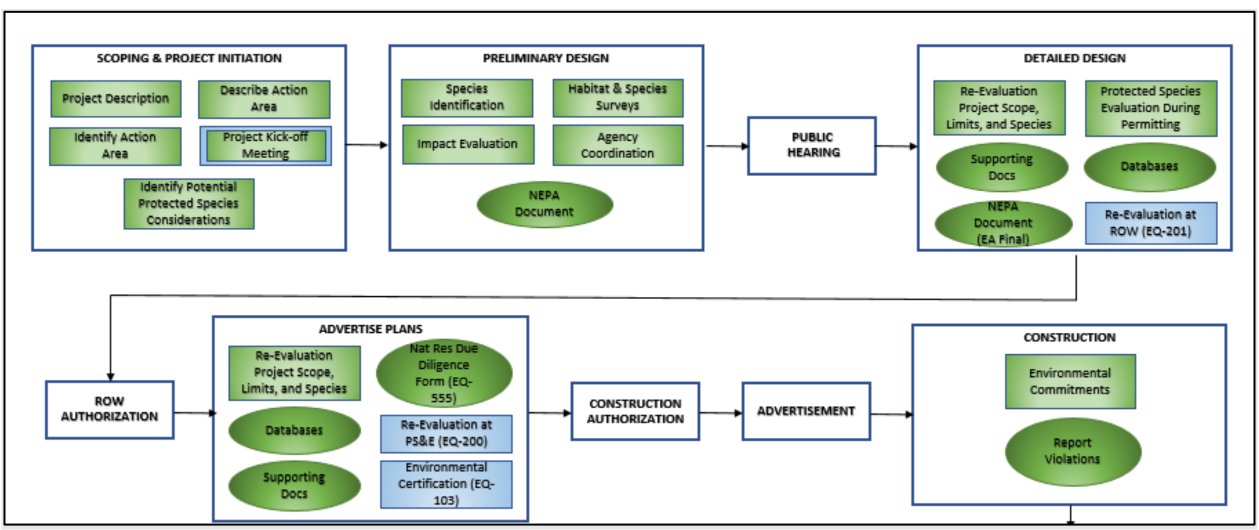

Figure 2-15. Overview of the transportation project development process. The consideration of wildlife crash countermeasures should be started at the project scoping phase and re-evaluated at preliminary design.

The primary types of transportation projects that should be evaluated for potential opportunities for incorporating wildlife enhancements to improve driver safety while also benefiting safe wildlife passage and habitat connectivity, include, but are not limited to:

- New roadway alignments;
- Road widening or lane additions to existing roadways;
- Significant realignment of existing roadways; and
- Bridge and culvert replacements.

The identification of intersection points of elevated WVC occurrence rates with proposed transportation projects early during project development can increase the successful implementation of wildlife crash countermeasures.

Best Practices

The following are best practices to identify wildlife crash countermeasures early during transportation planning and project development:

- Consider whether a proposed roadway project will create or worsen a barrier to habitats and wildlife movement corridors or provide an enhancement opportunity to improve wildlife connectivity and/or driver safety.
- Identify adjacent underpasses (e.g., bridge and culverts) where cost considerations for wildlife passage enhancements could be added during early project scoping. For example, in the vicinity of a high WVC occurrence area, identify if there are existing bridge or culvert structures within a 0.50- to 1-mile buffer where directional fencing could be installed to guide wildlife to an existing undercrossing.
- Consider existing investments, adjacent land uses, land protection status and the compatibility of those designations with promoting safe wildlife passage.
- Identify focal species for the planning efforts focused on habitat connectivity and safe wildlife passage. Consider whether additional site-specific wildlife movement or road mortality data are required before the appropriate type and location of wildlife enhancement can be identified.
- Include potential project costs for any long-term monitoring, data collection, and reporting of wildlife mitigation to support cost-benefit analyses and decision making. Add these potential costs into project cost estimating sheets.
- Identify stakeholders and collaborate with key partners to align project efforts for consistency.

Project Cost Implications

The cost for wildlife crash countermeasures can vary widely depending on site conditions; therefore, it is critical to weigh the costs and benefits of implementing wildlife crash countermeasures in relation to the overall project scope and budget. As an example, VDOT targeted a section of I-64 near the Afton Mountain area (Augusta and Nelson counties) for safety and mobility improvements because of a high number of vehicle crashes and traffic stoppages. This east-west segment of I-64 has an annual average daily traffic volume of 27,000 and 49,000 vehicles. Deer-vehicle collisions were the third most frequent police-reported type of crash along this section.

To provide VDOT with mitigation options to reduce deer-vehicle conflicts, VTRC researchers conducted a study that evaluated the activity and behavior of white-tailed deer and other wildlife near two existing unfenced underpasses along I-64. As a result of monitoring data collection, the study recommended the installation of up to 1 mile of 8-feet-high exclusionary fencing along eastbound and westbound lanes at both underpass locations (Donaldson and Elliott 2021). The costs for the directional deer fencing materials and installation ranged from $12 to $29 per linear foot. When all costs associated with site preparation, traffic control (during installation), fencing materials, and long-term maintenance of the study area were factored in, the total cost was estimated to be $265,000 per site (Donaldson and Elliott 2021). However, the fencing installation resulted in an average savings per site of $2,348,415 due to deer crash reductions, predominantly in the form of property damage savings to drivers, realizing a 1.8-year return on investment (Donaldson and Elliott 2021). The results of the study highlighted that the overall cost-benefit of installation of wildlife crash countermeasures not only improved driver safety improvements (as measured by reductions in property damage, injuries, and fatalities), but also resulted in considerable cost savings.

Conclusions

Data Collection Standards*.* As with any transportation safety improvement project, evaluating the effectiveness of wildlife crash countermeasures will help justify the countermeasure costs and will provide information regarding whether similar improvements should be conducted on other road segments. The need for national data collection standards, including for carcass retrieval data and standardized methods, have been identified. The FHWA has indicated one challenge for monitoring the effectiveness of wildlife-vehicle crash mitigation is the lack of reliable standardized and spatially precise data on the location of WVCs and animal carcass removal (Huijser et al. 2008). Additionally, crash and carcass data collection are largely focused on large mammals and typically do not represent the impact of road mortality to other at-risk species including smaller terrestrial wildlife species, federally protected species, or species designated as Species of Greatest Conservation Need (SGCN) in Virginia's State Wildlife Action Plan. The urgent need for standardized data focused on wildlife-vehicle collision locations has accelerated recently across the U.S. with the passage of the Infrastructure Investment and Jobs Act (IIJA). Among other funding programs in IIJA in which wildlife crash countermeasures may be eligible, IIJA includes a $350 million Wildlife Crossing Grant Program to fund the construction of wildlife road crossings, provided there are data to support and guide the decisions. As funding opportunities are pursued when appropriate, the accuracy of crash and carcass removal data is a major factor.. As more research and monitoring data on wildlife movements are collected, this information will direct where and how to maximize returns on investments in transportation infrastructure projects to benefit both humans and wildlife.

Cost-Benefit Analyses. Long-term monitoring data of wildlife crash countermeasures will provide critical information for evaluating the cost-benefit analyses of these structures. The long-term maintenance needs (e.g., fencing material repairs/replacement following storm damage, vegetation removal from culvert passage openings, level of effort of DOT maintenance staff to perform long-term maintenance, possible lane closure costs) of crossing structures has not been well studied or evaluated. Having more substantial long-term monitoring and maintenance costs will add to the realization of the value of installing wildlife crash countermeasures over time. Additionally, a standard set of metrics (e.g., reduction in wildlife carcasses, reduction in wildlife-vehicle collisions, etc.) to collect as pre- and post-monitoring project data would add to the cost-benefit analyses to installing wildlife crash countermeasures (Huijser et al. 2008).

Development of Wildlife-Vehicle Conflict Risk Predictive Models*.* The next logical step that could build from the WVC information provided here would be to develop a WVC risk analysis that would identify segments of roads that are at the highest risk of large mammal collisions. The road risk model could be developed using metrics of various road, traffic, and environmental factors such as: road right-of-way width; road curvature; Annual Average Daily Traffic or comparable traffic data; time of day or season of large mammal collision; and surrounding environment including land cover type, slope, and topography.

Chapter 3
Wildlife Biodiversity Resilience Corridors

Background

The Code of Virginia (§ 29.1-578 and § 29.1-579) requires that this Plan identify wildlife habitat corridors. The legislation also infers that these corridors should be comprised of high quality habitats for priority species and ecosystem health, including habitats for at-risk species and Critical Habitat (i.e., for species afforded protection under the federal Endangered Species Act, Critical Habitat are areas that are designated as essential for the conservation of the species).

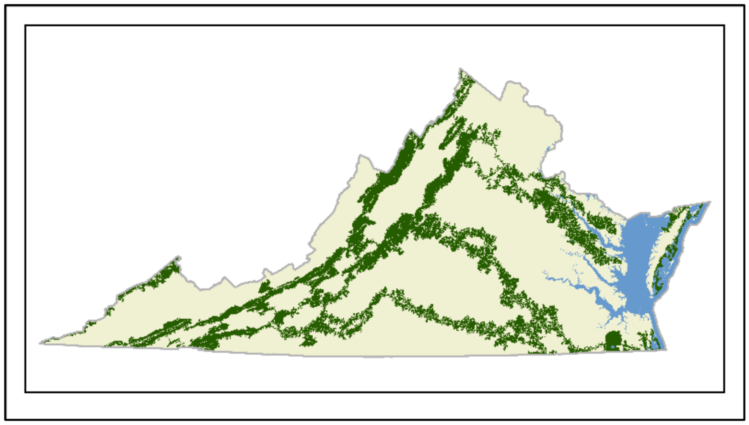

Figure 3-1. Wildlife Biodiversity Resilience Corridors in Virginia.

The WCAP Biodiversity Task Team determined that the best available planning tools to serve as the foundation of wildlife habitat corridor identification, for the purpose of this Plan, are the Virginia Natural Landscape Assessment (VaNLA) and ConserveVirginia. These two conservation tools are maintained by the VDCR to guide land conservation within the Commonwealth, prioritizing for significant biodiversity, ecosystem health, high quality habitats, at-risk species, and species protected under state and federal laws.

This chapter describes the methodology used to identify the high priority wildlife corridors in Virginia and presents these corridors as Wildlife Biodiversity Resilience Corridors (WBRCs). The inclusion of the “biodiversity” and “resilience” terms for these corridors is intentional. Biodiversity is the biological variety of life on Earth, including all species, their genetic variation, and their assemblages in communities and ecosystems. Resilience, as it pertains to this Plan, refers to the capacity of ecosystems to retain their ecological integrity, functions, and services to continue supporting biodiversity as land use and environmental conditions change over time, e.g., such as from climate change. Thus, in this Plan, with the use of VaNLA and ConserveVirginia as the foundational tools, it results in identifying corridors that support conserving Virginia’s native biodiversity and habitats for long-term sustainability.

Habitat Connectivity and Corridors

Habitat loss, be it from shifts in natural communities, degradation, or destruction, is one of the greatest threats to biodiversity (Brooks et al. 2002). While some habitat is lost to species through natural causes, the vast majority of habitat loss is directly linked to human activities at local and global levels. At the local level, conversion of natural lands to residential and commercial development is the primary mechanism by which habitat is lost permanently in Virginia. Furthermore, human-caused barriers like roads and dams can prevent organisms from moving through the landscape to access suitable habitats when their local habitats have been degraded or destroyed. In addition, human-caused barriers to habitat connectivity will exacerbate the effects of global climate variability and change on Virginia's native biodiversity. For example, climate change can cause loss of biodiversity when species do not have enough time to adapt to new conditions, when they cannot find refugia within which to survive periods of unfavorable conditions, or when they do not have the ability to move through connected landscapes to find suitable habitat. Preserving and restoring the connectivity of continuous, high quality natural lands and waters throughout the Commonwealth of Virginia will attenuate some of the negative impacts from anthropogenic barriers, such as developed lands, roads, and dams, as well as support the adaptive ability of species shifting their distributions as the climate changes.

Without proper planning, the conversion of natural lands to residential and commercial development can occur in decentralized and scattered patterns, consuming a substantial amount of land and causing unnecessary habitat fragmentation of the landscape. Such has been the case in Virginia in recent decades. The consequences include not only lost habitat and natural corridors, but also the degradation of important ecosystem services that keep our air and water clean, assist in climate regulation, and reduce the impacts of natural disasters. Ecosystem services often are overlooked as landscapes are developed largely because traditional economic analyses that incorporate the financial benefits of development usually do not include the financial benefits of ecosystem services. Studies have estimated that ecosystem services contribute as much or more to the global economy as do marketplace processes (Costanza et al. 1997) and that they can result in a return on investment in excess of 100 to 1 when natural lands are conserved (Balmford et al. 2002).

Loss of habitat connectivity can have significant impacts on species. Habitat fragmentation results in loss of interior forested habitat, facilitates colonization by invasive species, and introduces new predator/prey relationships along a habitat corridor and within adjacent habitats. Depending upon the surrounding landscape, habitat fragmentation also can result in ecological similarities to actual islands surrounded by water. Populations of a species in isolated habitat patches may experience decreased genetic exchange with populations in other habitat fragments, which can lead to inbreeding and eventually local population extinctions. Even seemingly healthy populations in isolated habitat patches can experience increased vulnerability to local extinctions caused by catastrophic weather events, sudden disease outbreaks or excessive predation. When a local extinction of a species occurs, isolated habitat patches are less likely to be recolonized when there are anthropogenic or even natural barriers in the landscape.

A network of natural lands, i.e., an interconnected system of habitat corridors and patches, with road enhancements that allow wildlife to cross safely, can attenuate the negative consequences of habitat fragmentation. Landscape corridors—strips of natural habitat that connect patches of similar habitat—have been shown to increase exchange of animals among patches and to facilitate dispersal of pollens and seeds (Tewksbury et al. 2002). Studies have concluded that landscape corridors are valuable conservation tools (Bier and Noses 1998) that are necessary for conservation of biodiversity (Damschen et al. 2006). Short and wide corridors are better than those that are long and narrow, and width is positively correlated with abundance and species richness of birds, mammals, and invertebrates (Lindenmayer and Franklin 2002). Corridors should also make use of nodes, small pieces of habitat that act as stepping stones and greatly facilitate movement of species populations among patches.

Identifying Wildlife Biodiversity Resilience Corridors

Existing conservation planning tools developed for Virginia were the foundation for the statewide WBRCs identified in this Plan. The Virginia Department of Conservation and Recreation has developed several landscape-level tools for conservation of networks of habitat for at-risk and endangered species, to support high biodiversity, and to support distribution shifts of species that are affected by climate change. The VaNLA, which is in its third decade of use, falls under the umbrella of Virginia ConservationVision (https://www.dcr.virginia.gov/natural-heritage/vaconvision). Virginia's land conservation atlas contains nine tools that can be used to target land conservation for a variety of values. The VaNLA is a landscape-scale, geospatial analysis for identifying, prioritizing, and connecting important natural lands. ConserveVirginia, which was first released in 2019 and codified into law in 2021 (§ 10.1-104.6:1), is the Commonwealth's land conservation strategy focused on only the most important areas to conserve for a variety of values important to citizens. The products of each of these tools will be described below for a full understanding of why and how they were used in this Plan to identify the WBRCs.

The VaNLA uses land cover data to identify natural habitats called Ecological Cores, which are large patches of natural land with at least 100 acres (40.5 hectares) of continuous interior wildlife habitat (Figure 3-2). Interior wildlife habitat begins 100 meters (328 feet) inward from edges caused by fragmenting features, such as roads, utility corridors, and other developed lands, and the 100-meter-wide edge zones are added back to the interior areas to create Ecological Cores. Smaller features called Habitat Fragments, with 10 to 99 acres (4 to 40.5 hectares) of interior wildlife habitat, are also included in the VaNLA because they support other VaNLA features and because they are important in localities with few large patches of natural land.

The predominant land cover in Ecological Cores statewide is forest, but marshes, beaches, and dunes are significant components where they are abundant and meet minimum size requirements. Ecological Cores are prioritized by ecological integrity ranks (from C1: Outstanding Ecological Integrity to C5: General Ecological Integrity) to reflect the wide range of important benefits and ecosystem services they provide, including biodiversity conservation, wildlife habitat, aesthetic values, recreational opportunities, and protections for air and water quality. Specifically, the variables used to prioritize the ecological integrity of Ecological Cores in the VaNLA, and to represent biodiversity, include the following:

- Important habitats for imperiled species and SGCN, as identified in Nature's Network (source: North Atlantic Landscape Conservation Cooperative);
- Threatened and Endangered Species Waters (source: VDWR); and

Wildlife Biodiversity Resilience Corridor Data Sources

Virginia Natural Landscape Assessment
https://www.dcr.virginia.gov/natural-heritage/vaconvisvnla

ConserveVirginia
https://www.dcr.virginia.gov/conservevirginia/

Nature's Network
http://www.naturesnetwork.org/

Threatened and Endangered Species Waters
https://vafwis.dgif.virginia.gov/fwis/

Natural Heritage Conservation Sites and Stream Conservation Units
https://www.dcr.virginia.gov/natural-heritage/nhdeinfo

National Wetlands Inventory
https://www.fws.gov/program/national-wetlands-inventory

Derived Indices of Habitat Diversity and Integrity

- Topographic Relief
- Size and Depth
- Anthropogenic Isolation
- Interior Forest Streams

Derived Impedance Surface
https://www.natureserve.org/products/modeling-landscape-condition
(included Landscape Condition)

- Natural Heritage Conservation Sites and Stream Conservation Units (source: VDCR).

Additional variables that addressed habitat diversity and resilience within the VaNLA include the following: variety of natural wetlands, topographic variability, degree of anthropogenic isolation, length of interior streams, maximum depth, and total size. (Full descriptions of these variables can be found in Appendix C.)

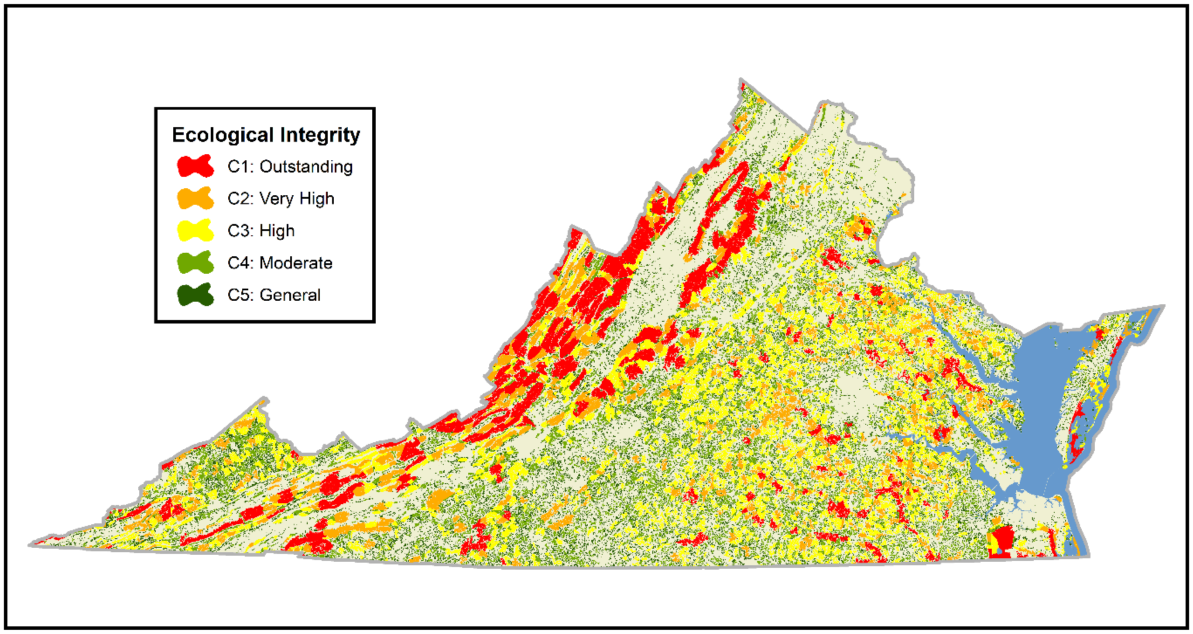

Figure 3-2. Ecological Cores of the Virginia Natural Landscape Assessment ranked by ecological integrity. (VDCR)

The VaNLA connects the highest priority Ecological Cores, i.e., those classified as having Outstanding Ecological Integrity (C1) or Very High Ecological Integrity (C2), to form the backbone of a statewide network known as the Natural Land Network (NLN) (Figure 3-3). This was done via creation of an impedance model that represented resistance to movement of wildlife and plant propagules (e.g., seeds) through the landscape. This model started with current land cover and reduced impedances cumulatively for riparian habitat, interior habitat, high biodiversity, land protection, core rank, and management for biodiversity. Impedances were increased cumulatively for lands that were too close to urban development or coincident with major roads (except where suitable underpasses existed), expansive open water, extensively flooded lands, steep slopes, or excessively narrow strips of natural land. Although largely redundant to variables already included, NatureServe's Landscape Condition model was incorporated into the latest version of the impedance model (https://www.natureserve.org/products/modeling-landscape-condition).

Using the impedance model, hundreds of routes of least resistance between pairs of highest ranked Ecological Cores were identified. The model guided corridors as much as possible through public and private natural lands with biological significance, ecological value, and protections from natural and anthropogenic disturbances. Where major roadways were intersected, and where possible, the model funneled corridors to existing bridge underpasses and large box culverts associated with riparian habitats to improve corridor viability by potentially providing safer passages for wildlife.

The model also guided corridors through lower-ranked Ecological Cores and Habitat Fragments (i.e., C3, C4, and C5), which were all eventually integrated into the NLN to provide additional habitats, resilience, and increased suitability for sensitive species. The centerline paths were reviewed over aerial photography while referencing environmental data to make sure they traversed the widest-possible, most-diverse, and best-condition natural lands. As a result of this review, many paths were deleted where better routes existed, and many others were edited to improve them. The final centerline paths were expanded to a total width of 300 meters, thereby including 100 meters of interior habitat along their entire length and 100 meters of buffer on each side, to enhance the integrity and resilience of the natural corridors.

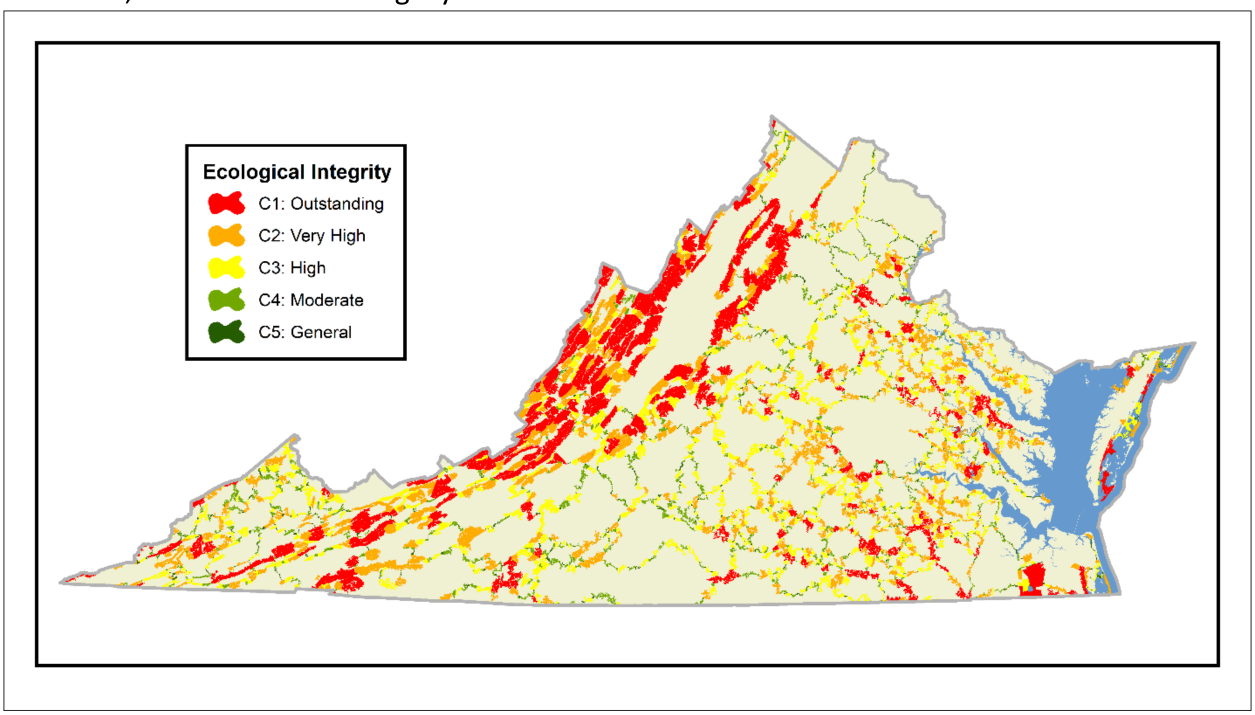

Figure 3-3. The Natural Lands Network is a subset of the Virginia Natural Landscape Assessment that shows connections between all the highest ranked Ecological Cores (C1 and C2). These corridors of natural land also include lower-ranked cores that intersect them. (VDCR)

Along with the VaNLA, ConserveVirginia has become a key tool in guiding state investments to ensure the best conservation outcomes. Priority components of the VaNLA were selected and enhanced for natural resilience to develop an input for the Natural Habitat and Ecosystem Diversity category of ConserveVirginia. With strong consideration of the concept of representativity (measure of whether a given area contains habitat / biotope types, species assemblages, ecological processes or other natural features that are characteristic of the larger region), a subset of the corridors from the NLN were selected to identify connections among ecoregions and enhanced to create the Resilience Corridors (Figure 3-4), which is a layer within the Natural Habitat and Ecosystem Diversity category of ConserveVirginia. (The five major ecoregions of Virginia are connected via the Resilience Corridors: Coastal Plain, Piedmont, Blue Ridge, Valley and Ridge, and Appalachian Plateau.)

Along with the NLN, the goal of the Resilience Corridors is to keep biodiverse and representative natural lands in Virginia connected to allow distribution shifts by species populations over generations as the climate changes and the landscape becomes more developed. These corridors could facilitate distribution shifts between elevations or latitudes, which will be especially important as the climate changes. Since the highest priority Ecological Cores are the foundation of the Resilience Corridors, they already represent areas of high biodiversity, high intactness relative to surrounding areas, and high environmental diversity, meaning they have high resilience and provide a great variety of refugia within which species could persist over time. Resilience Corridors are provided with alternate routes where they pass through pinch points and other vulnerable areas, and they were widened by additions of adjacent Ecological Cores and Habitat Fragments that provide extra habitat and buffer to increase functionality and long-term viability. The idea is to provide a variety of connected and intact habitats within Resilience Corridors so that species populations could shift within suitable habitats with minimal traverses through marginal or unsuitable lands. Some Resilience Corridors identify potential connectivity for aquatic, wetland, riparian, terrestrial, interior, and even ecotonal species, all within the same corridors. Since Resilience Corridors were developed from ecologically important natural lands currently on the landscape, they are likely already functioning as corridors for a wide range of species.

The ConserveVirginia Resilience Corridors, as described above, were adopted for this Plan as shown in Figure 3-4, with a modification to finalize Virginia's WBRCs. The members of the WCAP Biodiversity Task Team agreed that additional connectivity needed to be identified for northern Virginia, despite much of that area having been converted to farmland and residential and commercial development. The two upper peninsulas of Virginia, on either side of the Rappahannock River, were selected for this addition due to the following reasons: the NLN identified viable connections there; the Rappahannock River contains important habitats for anadromous fish and rare aquatic organisms; water quality in the Rappahannock River and the Chesapeake Bay is vital for healthy ecosystems, and forests are the best land cover in Virginia for maintaining water quality; and this region is threatened by sprawling development. Thus, additional corridors along the Rappahannock River watershed were developed using the same methodology as for the ConserveVirginia Resilience Corridors and added to those features to create the final statewide WBRCs (Figure 3-5) for this Plan.

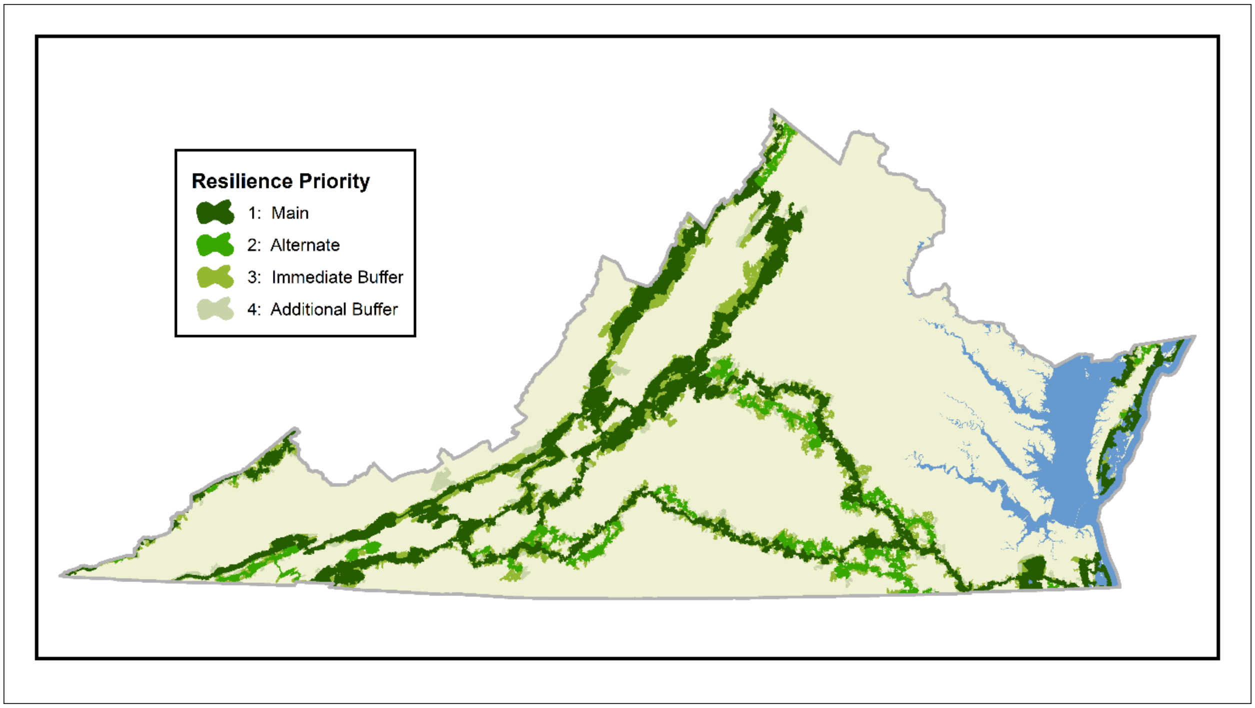

Figure 3-4. ConserveVirginia Resilience Corridors ranked by priority, where priorities 1 and 2 are based directly on the NLN and priorities 3 and 4 are buffers of proximate Ecological Cores and Habitat Fragments. (VDCR)

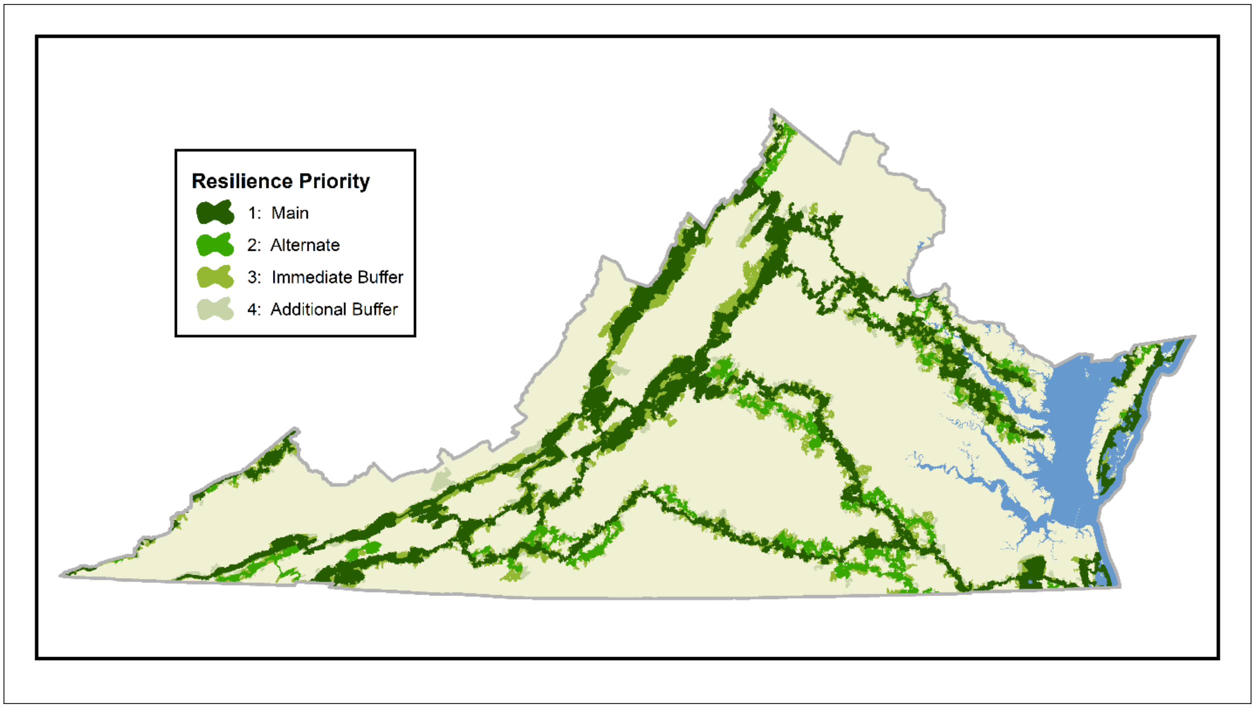

Figure 3-5. The Wildlife Biodiversity Resilience Corridors ranked by priority. These Wildlife Biodiversity Resilience Corridors include a new set of corridors for the upper peninsulas, on either side of the Rappahannock River, that were developed using the same methodology as for the ConserveVirginia Resilience Corridors.

Conclusions

These statewide WBRCs were designed with a focus on terrestrial habitat connectivity for native biodiversity resilience; however, there are two types of additional habitat corridors that need to be identified during future WCAP iterations:

1. Aquatic Organism Passage (AOP): Although the WBRCs likely are providing benefits to aquatic resources, a future analysis is needed to identify AOP barriers (e.g., culverts and dams) and to target habitat connectivity priorities for AOP needs. Existing national, state, and regional data sets relevant to AOP barriers have been developed (by various organizations) with different methodologies; additional work is needed to normalize these data across the Commonwealth to identify aquatic habitat corridor priorities for this Plan.

2. At-risk Species and Other Species of Interest: The WBRCs likely do not fully represent all habitat corridors that may be important to at-risk species (federally-protected species, state-protected species, and SGCN) or other species of interest (e.g., elk, small- to medium-sized mammals, amphibians, and reptiles). Species-specific wildlife corridors will need to be identified for priority species.

In addition, it should be noted that the WBRCs are not fully representative of every natural habitat type within Virginia due to the historical influences and patterns of human land uses across our landscapes. For example, for the lands west of the Coastal Plain, *high quality natural* open habitats (e.g., fire-dependent grassland and scrub-shrub habitats) may be particularly under-represented in the WBRCs since these habitats were more prevalent in pre-European settlement times (before fire suppression policies). In modern times, open lands largely are the result of human land uses (agricultural fields, mowed fields, and lawns), and thus they would not be classified as natural lands within the VaNLA, even though these lands can provide habitat value to certain wildlife species. However, within the Coastal Plain, natural open habitats are well-represented due to, in part, how marshes constitute significant expanses of the Ecological Cores within the WBRCs.

Finally, although these WBRCs constitute important, coarse-scale wildlife corridors in Virginia based on the best available data at this time, this does not preclude the need for identifying, protecting, and restoring additional habitat corridors at finer spatial scales across the Commonwealth. For local or regional planning initiatives, organizations can use the Natural Lands Network of VaNLA (see Figure 3-3 in Chapter 3) to identify additional habitat corridors at finer spatial scales than the WBRCs.

Chapter 4
Opportunities for Further Evaluation

Background

This chapter identifies areas across Virginia that may be opportunities for future wildlife crash countermeasures and other conservation measures. These opportunities are as follows:

- Promote Driver Safety: *Areas of High Wildlife-Vehicle Conflict Occurrences*
- Improve Wildlife Corridor Connectivity: *Wildlife Biodiversity Resilience Corridors*
- Advance Mutual Benefits: *Nexus Areas*

WHERE CAN I FIND THESE DATA PRODUCTS?

Visit the website:
https://dwr.virginia.gov/wildlife/corridors/

These opportunities are available as data product downloads from the VDWR website (see inset box to the right). Note that for most of these opportunities, further evaluation of specific sites is necessary to determine whether wildlife crossing and other crash countermeasures are warranted.

Opportunities to Improve Driver Safety: Areas of High Wildlife-Vehicle Conflict Occurrences

In Chapter 2, WVC occurrence rates per road segment were analyzed and then presented in Figure 2-6, with the road segments classified by WVC occurrence rate categories. Based on this WVC analysis, the WCAP leadership team identified areas experiencing the highest WVC occurrences. This includes road segments within the top 0.1%, 1%, 5% and 10% WVC occurrence rate categories, as shown in Figure 4-1. Wildlife-vehicle conflict occurrence rates in these road segments are 0.88 to 5.27 reported conflicts per mile per year.

For organizations and agencies focused on transportation and promoting driver safety, a reasonable course of action is to further evaluate the Areas of High WVC Occurrences shown in Figure 4-1, starting with the road segments showing the highest WVC occurrence rates (top 0.1%) if funding is limited, to determine where wildlife crash countermeasures are warranted and feasible. For example, Chapter 2 (*Wildlife-Vehicle Conflict*) demonstrates that areas within northern Virginia experience some of the highest rates of WVCs in the Commonwealth; these WVC locations in northern Virginia and other locations experiencing high rates of WVCs likely should be examined further to identify priority opportunities for wildlife crossing road modifications. Additional analysis is needed to develop a prioritization framework for road segments experiencing high rates of WVCs, wildlife enhancement opportunity areas, and the prioritization of wildlife crossing projects.

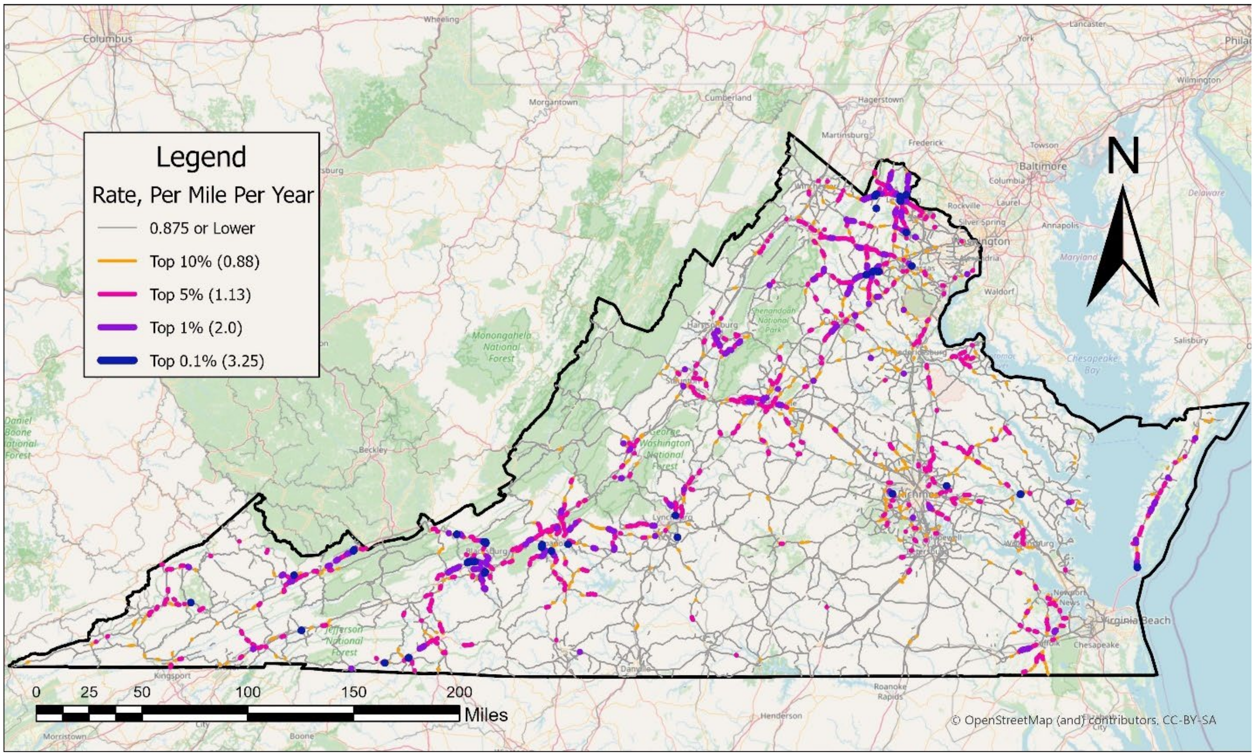

Figure 4-1. Areas of High Wildlife-Vehicle Conflict Occurrences (2013-2020) are classified by the top 0.1%, 1%, 5% and 10% occurrence rates. The parenthetical values state the minimum number of WVCs per mile per year.

Opportunities to Improve Wildlife Corridor Connectivity: Wildlife Biodiversity Resilience Corridors

As discussed in Chapter 3, the WBRCs (see Figure 4-2) constitute statewide coarse-scale wildlife corridors of natural lands that currently exist, based on the best available data at this time. For conservation organizations and agencies, the WBRCs represent opportunities for conserving, enhancing, and restoring connectivity within these important wildlife corridors, through actions such as land protection strategies, habitat restoration, and wildlife crash countermeasures along roads. Within these WBRCs, these conservation measures ideally should begin with the central portions that were based on the Natural Lands Network of the VaNLA, as described in Chapter 3. These are the areas attributed to “Priority 1” in Figure 3-4. Conservation actions also can be pursued, as opportunities arise, within the alternate corridor routes, which are attributed to

"Priority 2," and the additional Ecological Cores and Habitat Fragments within 100 meters or 500 meters of the first two priorities (attributed to "Priority 3" and "Priority 4," respectively).

In addition, identification of these WBRCs does not preclude the need for identifying, protecting, and restoring additional habitat corridors at finer spatial scales across the Commonwealth. For example, the Natural Lands Network of the VaNLA (see Figure 3-3 in Chapter 3) can be used to identify additional habitat corridors that may be relevant for local or regional conservation planning initiatives. This in turn could aid with decision-making on land conservation investment and prioritization strategies to benefit wildlife corridor connectivity. Furthermore, additional work likely is needed to define habitat corridors for at-risk species (federally-protected species, state-protected species, and SGCN) and other species of interest (e.g., elk, amphibians, and reptiles) whose important corridors were not fully represented within the WBRCs; these species-specific corridors will provide key information to define Wildlife Crossing Concern Areas for these types of species. (See Appendix D for more information about Wildlife Crossing Concern Areas and an initial list of these areas from VDWR biologists.)

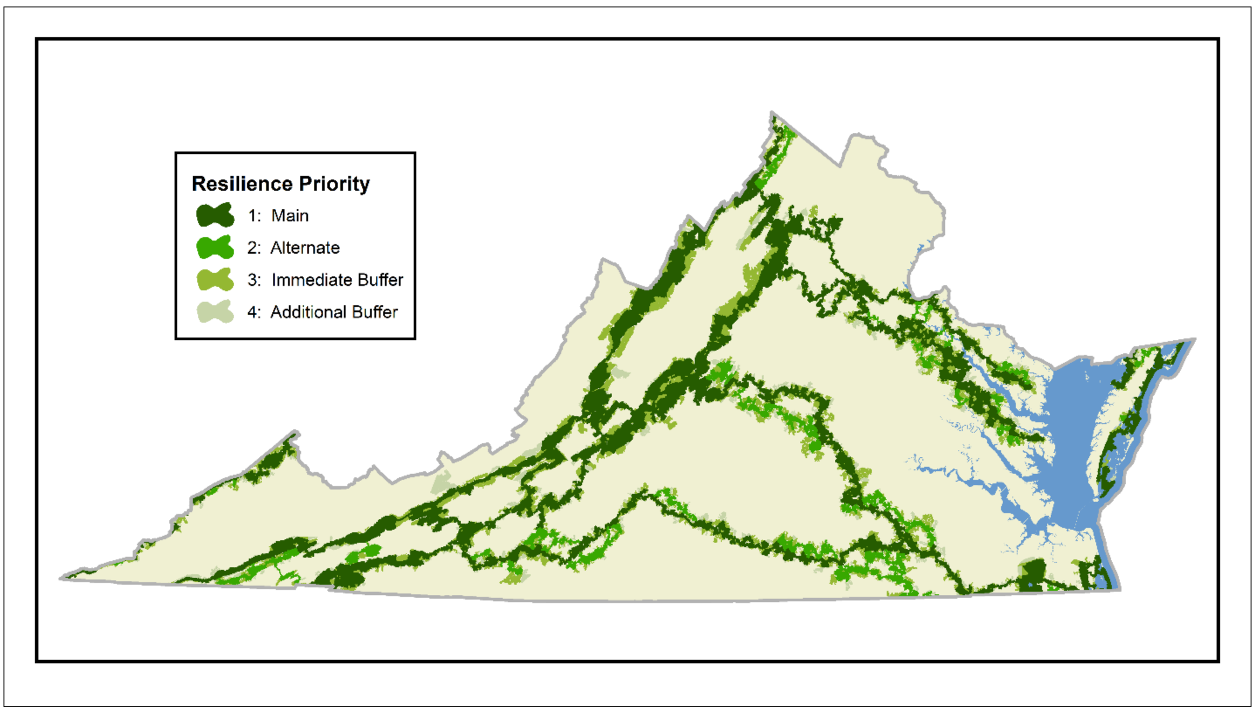

Figure 4-2. Wildlife Biodiversity Resilience Corridors.

Opportunities for Advancing Mutual Benefits: Nexus Areas

Nexus Areas represent opportunities where wildlife crossings and crash countermeasures could provide both driver safety and wildlife corridor conservation benefits. That is, these Nexus Areas are associated with a WBRC (as defined within Chapter 3) and at least one Area of High WVC Occurrences (see above section).

Nexus Areas were identified by a GIS analysis of the intersection of the WBRCs and the Areas of High WVC Occurrences. Specifically, the WBRC dataset was divided into two sets of feature types, “Corridor” and “Buffer,” with the former set comprised of corridors that corresponded directly to the Natural Lands Network (see Figure 3-3 in Chapter 3) and the latter set containing Ecological Cores and Habitat Fragments in close proximity to features in the “Corridor” set (see Figure 3-5 in Chapter 3). The WBRC data were then spatially overlaid with the Areas of High WVC Occurrences data in GIS, and then the available spatial information was summarized within 25-square mile hexagons. The spatial overlay also involved performing spatial summary processes and table joins to assemble relevant attribute information. This analysis resulted in the identification of 26 Nexus Areas across the state (Figure 4-3); available attribute information for these Nexus Areas is provided in Table 4-1.

For these Nexus areas, additional desktop analyses and site-specific assessments are required to understand the factors driving WVCs on the associated roads, target specific road sites that are problematic, and identify wildlife crossing enhancement opportunities. Feasibility studies at these road sites will be required to assess the options and practicalities for wildlife crossing modifications. For Nexus areas, additional analysis is needed to develop a process on how to prioritize wildlife enhancement projects while taking into consideration limited funding opportunities.

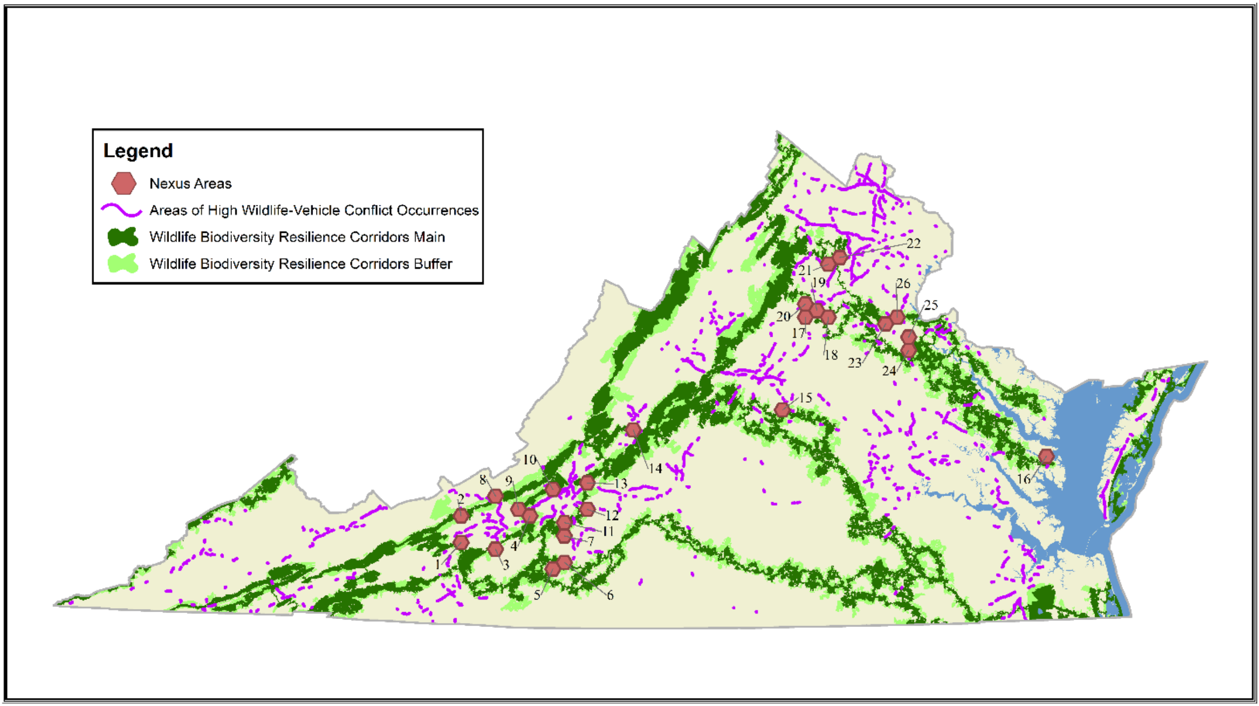

Figure 4-3. Nexus Areas, as defined by an intersection of the Wildlife Biodiversity Resilience Corridors and the Areas of High Wildlife-Vehicle Conflict Occurrences. The numbers correspond to the Nexus Area column in Table 4-1.

Table 4-1. Attributes associated with the Nexus Areas.

Nexus Area #	County / City	Road Attributes within Nexus Area	
		Associated Roads[1]	Intersects Bridge or Box Culvert[2]
1	Pulaski County	R-VA IS00081NB	NO
		R-VA IS00081SB	NO
		R-VA SR00099EB	NO
		R-VA077SC00611EB	NO
2	Pulaski County, Giles County	R-VA SR00100NB	NO
3	Floyd County, Montgomery County	R-VA SR00008NB	NO
4	Montgomery County, Roanoke County	R-VA IS00081SB	NO
		R-VA US00011NB	NO
		R-VA US00011SB	YES
5	Franklin County	R-VA SR00040EB	NO
6	Franklin County	R-VA SR00040EB	NO
7	Franklin County	R-VA US00220NB	NO
		R-VA US00220SB	YES

Nexus Area #	County / City	Road Attributes within Nexus Area	
		Associated Roads[1]	Intersects Bridge or Box Culvert[2]
8	Giles County, Montgomery County, Craig County	R-VA US00460EB	NO
		R-VA US00460WB	NO
9	Montgomery County	R-VA IS00081SB	YES
10	Salem City, Roanoke County, Botetourt County	R-VA IS00081NB	NO
		R-VA IS00081SB	NO
		R-VA IS00581NB	NO
		R-VA SR00311NB	YES
11	Franklin County, Roanoke County	R-VA US00220NB	NO
		R-VA US00220SB	YES
12	Franklin County, Bedford County	R-VA SR00024EB	NO
		R-VA SR00024WB	NO
13	Botetourt County, Bedford County	R-VA US00460EB	NO
		R-VA US00460WB	NO
14	Rockbridge County	R-VA IS00081SB	YES
15	Fluvanna County	R-VA SR00006EB	NO
16	Gloucester County, Mathews County, Middlesex County	R-VA SR00003EB	NO
		R-VA SR00198EB	NO
17	Madison County, Culpeper County	R-VA US00015NB	NO
18	Orange County, Culpeper County	R-VA US00522NB	YES
19	Madison County, Culpeper County	R-VA US00015NB	NO
20	Madison County, Culpeper County	R-VA US00029SB	YES
		R-VA023SC00633NB	NO
21	Rappahannock County, Culpeper County, Fauquier County	R-VA SR00229NB	NO
		R-VA US00211EB	NO
		R-VA US00211WB	NO
22	Fauquier County, Culpeper County	R-VA SR00229NB	NO
		R-VA US00211EB	NO
		R-VA US00211WB	NO
23	Spotsylvania County, Fredericksburg City, Stafford County	R-VA IS00095NB	YES
24	Caroline County	R-VA SR00002NB	NO
25	Spotsylvania County, Caroline County, Stafford County, King George County	R-VA SR00002NB	NO
26	Fredericksburg City, Stafford County	R-VA IS00095NB	YES
		R-VA IS00095SB	NO
		R-VA US00001NB	NO

[1] Associated roads are defined as the roads within the roads (top 10% road segments experiencing the highest WVC occurrence rates) and are identified by VDOT codes.
[2] Available spatial data indicate that a bridge or box culvert is associated with this road. This may provide a cost-effective opportunity to modify this infrastructure to improve wildlife corridor connectivity.

Funding Opportunities

The Nexus Areas may be particularly important opportunities for seeking competitive federal grant funds, such as under the Wildlife Crossings Pilot Program of the Infrastructure Investment and Jobs Act, which is focused on funding projects that both reduce wildlife-vehicle collisions and improve terrestrial and aquatic habitat connectivity. Furthermore, Table 4-2 outlines some additional federal funding opportunities for wildlife crossing and corridor enhancement projects.

Conclusions

Further investigation of specific Areas of High WVC Occurrences and Nexus Areas is required to understand the factors driving WVCs on the associated roads, target specific road sites that are problematic, and identify potential wildlife crossing and countermeasure opportunities. For example, an assessment of wildlife use along roads (e.g., through field studies of wildlife movements and/or carcasses proximate to roads) often may be required to target the specific road sites that may benefit from wildlife crossings and countermeasures. In addition, feasibility studies at these road sites would be required to assess the options and practicalities for wildlife crossing modifications. For the lands within the WBRCs, the wildlife corridor connectivity opportunities will also need further analysis, to target and prioritize sites that would benefit from conservation actions. Step-down or companion plans, tiering from this Plan, will be needed to fully address the habitat corridor and wildlife crossing needs for at-risk terrestrial and aquatic species and other species of interest. These additional analyses and plans will provide a framework for the development of targeted partnerships at local and regional-scales and the identification of on-the-ground, project opportunity areas.

Table 4-2. Sample federal grant programs available for funding wildlife crossing and corridor enhancement projects nationwide.

Federal Discretionary Grants		
Bipartisan Infrastructure Law (FY 22-26)		
Program Title	**Amount**	**Eligible Wildlife-related Enhancements**
Wildlife Crossings Pilot Program (23 USC Section 171)	$350 Million over 5 years	Projects and research to reduce wildlife-vehicle collisions while improving terrestrial and aquatic connectivity.
Rebuilding American Infrastructure with Sustainability & Equity (RAISE)	$7.5 billion	Wildlife related highway and bridge projects eligible under Title 23 USC Programs, and projects to improve aquatic connectivity by replacing or rehabbing culverts.
Bridge Investment Program (23 USC Section 124)	$12.5 billion over 5 years	Up to 5% annually may go to projects to replace or rehab culverts to improve flood control and habitat connectivity for aquatic species.
National Culvert Removal, Replacement, and Restoration Program (Culvert AOP Program, 49 USC Section 6703)	$1 billion over 5 years	Projects to replace, remove, repair culverts or weirs to restore anadromous fish passage.
Non-federal Programs		
Non-federal funding sources for wildlife crossings also need to be identified; such funds can serve as non-federal match for the federal grant programs listed above. For example, the Virginia Safe Wildlife Corridors Collaborative has proposed legislation to the Virginia General Assembly to appropriate approximately $5 million in state funds for wildlife crossings.		

Chapter 5
Plan Recommendations

Virginia's *Wildlife Corridor Action Plan* provides a strategic framework that will be expanded upon in future iterations, which are required to occur on four-year cycles. This first iteration includes statewide analyses focused on identifying areas with high occurrences of WVCs and identifying important wildlife corridors, with a key result being the overlap of these two areas (Nexus Areas). From an end user perspective, this Plan also offers three thematic pathways for decision-making for where future wildlife crossings and corridor enhancements may be warranted (Figure 5-1).

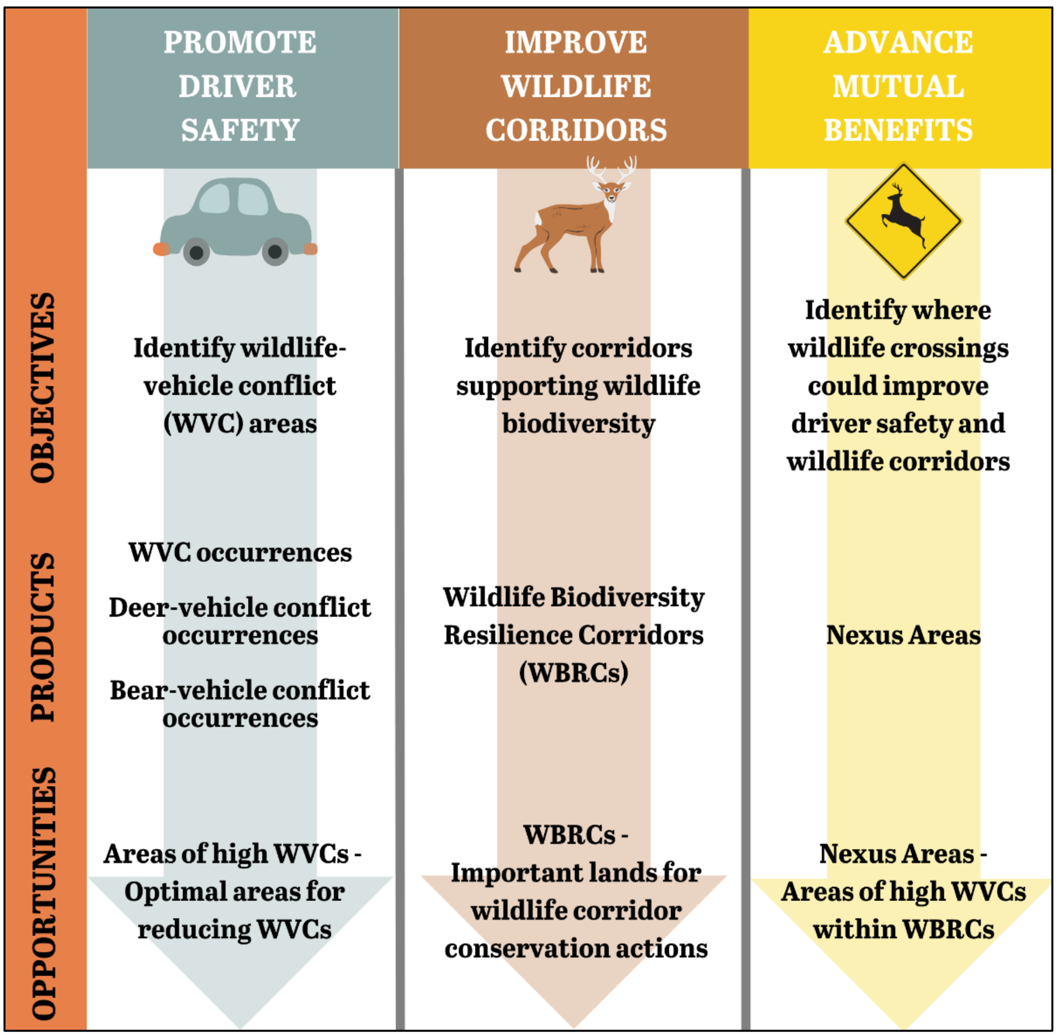

Figure 5-1. The conceptual framework for the Wildlife Corridor Action Plan provides three decision-making pathways to identify where future wildlife crossings and corridor enhancements may be warranted.

To lay a foundation for how this current Plan iteration can be improved and moved into on-the-ground implementation actions, the leadership team defined this Plan's limitations and data gaps and provided a list of future actions in the two sections below.

Plan Limitations and Data Gaps

Although this Plan constitutes Virginia's first *Wildlife Corridor Action Plan*, several limitations and data gaps remain to identify additional important wildlife corridors and specific road segments for wildlife crash countermeasures. These Plan limitations and data gaps are detailed in Table 5-1; they directly provide the justification for the recommendations for future actions (see below).

Future Actions

As a "road map" to identifying site-specific wildlife crossing project priorities, 15 actions are recommended (see Table 5-2); these will form the basis for future iterations of this Plan. To ensure progress on implementing these actions, it is highly recommended that a state interagency coordinating body and/or technical advisory committee is established to address key needs such as identifying dedicated staff and funding resources.

Table 5-1. Limitations and data gaps for the Wildlife Corridor Action Plan.[1]

Legislative Intent	Theme	Plan Limitations / Data Gaps
Intent #1: **Identify Wildlife Corridors**	**Improve Wildlife Corridors**	➢ ***Important habitat corridors for regional/local planning needs, at-risk terrestrial and aquatic species, and other species of interest were likely not fully represented within the Wildlife Biodiversity Resilience Corridors (WBRC).*** ▪ This Plan, with its WBRCs, does not presume to map important habitat corridors that may be more relevant for regional planning commissions or localities, at-risk species (federally-protected species, state-protected species, and Species of Greatest Conservation Need [SGCN]), or other species of interest (e.g., elk, small- to medium-sized mammals, amphibians, and reptiles). ▪ For example, although this Plan will be helpful for regional and local planning needs, the complexities of wildlife corridor planning (and of wildlife-vehicle conflict [WVC] analyses) will require additional data, partners, and expertise to complement this Plan's spatial data products to successfully address problematic WVC locations relevant to a planning authority's jurisdiction. ▪ For at-risk species and other species of interest, species-specific wildlife corridors may need to be identified to complement the WBRCs presented in this Plan.
Intent #2: **Identify Human Barriers to Wildlife Movement**	**Improve Wildlife Corridors** **Promote Driver Safety**	➢ ***Road barriers and other human barriers to aquatic organism passage (AOP) were not addressed.*** ▪ This Plan identifies WBRCs that are directly relevant to the habitat connectivity for terrestrial wildlife species. Although the natural lands of these WBRCs do provide benefits to aquatic resources, this Plan does not sufficiently analyze potential barriers for aquatic organism passage, such as culverts and dams. Existing national, state, and regional data sets relevant to AOP barriers have been developed (by various organizations) with different methodologies; additional work is needed to normalize these data across the Commonwealth to thus identify aquatic habitat corridor priorities, as well as opportunities for restoring connectivity for AOP. Additionally, not all barrier types and road stream crossings in Virginia have been assessed using a standardized AOP barrier assessment methodology. ▪ If identified early during the project scoping and cost estimating phase, road stream crossings represent key opportunities to integrate fish and wildlife passage improvements as part of future culvert, bridge, or transportation projects.

Legislative Intent	Theme	Plan Limitations / Data Gaps
Intent #2 continued from prior page		➢ ***Other human land uses potentially causing barriers for terrestrial wildlife corridor connectivity were not addressed.*** ▪ The legislation (§ 29.1-579) also identifies electrical transmission lines and pipelines as potential barriers to wildlife movement along habitat corridors; additional analysis will be required to assess whether any current powerlines and pipelines may be detrimentally impacting wildlife corridors. (However, the more effective timeframe to minimize fragmentation of habitat corridors by powerlines and pipelines is during the project planning phase, particularly during project siting.)
Intent #3: **Identify Wildlife Vehicle Conflict Areas**	**Promote Driver Safety**	➢ ***The police-reported WVC data represent a portion of actual WVCs occurring across the state.*** ▪ Reporting is limited to collisions with >$1500 in damages, so data are not collected for minor WVCs. ▪ Actual numbers of deer-vehicle collisions may be four to nine times greater than those reported to the police (Donaldson 2017). ▪ Road wildlife carcass data could augment the police-reported WVC data, but there is no comprehensive statewide dataset. ▪ Predictive models may also be necessary to augment WVC data gaps. For example, a predictive model likely is needed to identify road segments that are at higher risk of large mammal collisions. This road risk model could be developed using the following road, traffic, and environmental metrics including, but not limited to the following: road right-of-way width; road curvature; Annual Average Daily Traffic or comparable traffic data; time of day or season of large mammal collision; and surrounding environment including land cover type, slope, and topography. ➢ ***Wildlife crash and carcass removal data collection standards lack reliable standardization.*** ▪ The Federal Highway Administration has indicated one challenge for reducing WVCs is the lack of reliable standardized and spatially precise data on the location of WVCs and animal carcass removal (Huijser et al. 2008). This is a challenge and data gap identified on a national level across many state DOTs and is not specific to Virginia. In the development of this Plan, the leadership team directly experienced this challenge. It also should be noted that one future outcome of the Infrastructure Investment and Jobs Act is the development of a standardized methodology and template for states to voluntarily use in collecting and reporting WVC and animal carcass data (Paul et al. 2021). (In the future, citizen science applications may support collecting species-specific carcass data associated with roads, though public safety may be a limiting factor for the use of such citizen science applications.)

Legislative Intent	Theme	Plan Limitations / Data Gaps
Intent #3 continued from prior page		➢ ***Insufficient data for understanding WVC impacts for species other than deer and bear.*** ▪ The best available statewide WVC datasets were most relevant for understanding WVCs involving large mammals, in particular deer and bear. Although deer and bear logically pose greater risk to driver safety as compared to many other species, roads likely serve as a habitat connectivity barrier to other species such as federally-protected species, state-protected species, SGCN, elk, small- to medium-sized mammals, reptiles and amphibians, and various bird species (e.g., marsh birds that may fly low over roads along marsh habitats). In addition, WVCs often occur due to driver behavior and swerving to avoid hitting these smaller animals. Unfortunately, current state WVC and wildlife carcass data collection methods do not provide the specificity to consistently identify species beyond deer and bear.
Intent #4: **Prioritize Wildlife Crossing Projects**	**Promote Driver Safety** **Improve Wildlife Corridors** **Advance Mutual Benefits**	➢ ***Site-specific data were not available to identify specific sites where wildlife crossing projects are warranted and will be feasible.*** ▪ This Plan defines opportunity areas (Areas of High WVC Occurrences, WBRCs, and Nexus Areas) that need further evaluation before site-specific projects can be identified and prioritized. ▪ Additional desktop analyses and site-specific assessments are required to understand the factors driving WVCs within the opportunity areas, target specific road sites that are problematic, and identify wildlife crossing opportunities. ▪ Feasibility studies at these specific road sites will also be required to assess the options and practicalities for wildlife crossing modifications. ➢ ***Cost-benefit analyses and valuing of wildlife crossings are needed to support effectively prioritizing wildlife crossing opportunities for funding.*** ▪ On a national level, the lack of comprehensive data along with other confounding factors pose a difficulty to quantifying the ecological value of a wildlife crossing and other connectivity enhancements. To quantify pre-construction versus post-construction wildlife values, functional or ecosystem-based metrics would require extensive biological data for focal species and are only available for a limited number of species and locations. Pre- and post-construction monitoring data of a wildlife crossing can provide critical information for evaluating the cost-benefit of implementing and constructing these structures, although often long-term monitoring data are not available.

Legislative Intent	Theme	Plan Limitations / Data Gaps
Intent #4 continued from prior page		➢ ***This Plan does not comprehensively identify potential wildlife crossing needs for at-risk species and other species of interest.*** ▪ Due to how additional planning and analyses are required to identify important habitat corridors and areas of WVCs for at-risk species and other species of interest (including elk), it is not feasible yet to identify priority wildlife crossing sites for these species. ➢ ***Optimal road sites for wildlife crossing enhancements may be revised in future Plan iterations as more information and data become available.*** ▪ This current Plan iteration suggests that the Nexus Areas (where both driver safety and corridors can be improved) offer optimal opportunity areas to evaluate for wildlife crossing enhancements. However, completion of the Future Actions (identified in this Plan) will improve the selection and prioritization of wildlife crossing projects for implementation.
***Intent #5*: Provide a Public Data Portal**	**Supports All**	➢ ***The multiple data sources used for this Plan are not easily accessible at one online data portal.*** ▪ A website has been provided to host the Plan and links to the data sources used in this Plan (https://dwr.virginia.gov/wildlife/corridors/). However, not all of the data sources are available for download, and instead are only viewable. If all of the data were located at one online location within a geospatial viewer application, this could be more useful to conservation and transportation practitioners.
***Intent #6:* Update Plan Every Four Years**	**Supports All**	➢ ***For Plan updates and implementation, dedicated staff and funding resources need to be identified.*** ▪ Limited progress will be made on implementing the Future Actions (see Table 5-3) unless dedicated staff and funds are obligated.

[1] Acronyms used in this table: AOP = aquatic organism passage; SGCN = Species of Greatest Conservation Need; WBRC = Wildlife Biodiversity Resilience Corridor; WVC = wildlife-vehicle conflict

Table 5-2. Recommended future actions for the Virginia Wildlife Corridor Action Plan.[1]

Legislative Intent	Recommended Future Actions
Intent #1: **Identify Wildlife Corridors**	1.1. Identify at-risk terrestrial and aquatic species and other species of interest whose habitat corridor needs are not sufficiently addressed by the Wildlife Biodiversity Resilience Corridors (WBRC) (e.g., federally-protected species, state-protected species, Species of Greatest Conservation Need [SGCN], elk, small- to medium-sized mammals, amphibians, reptiles, and various bird species such as marsh birds). 1.2. Identify important habitat corridors for these at-risk terrestrial and aquatic species and other species of interest.
Intent #2: **Identify Human Barriers to Wildlife Movement**	2.1. For aquatic corridor connectivity, conduct aquatic organism passage (AOP) analyses to identify road-associated infrastructure and other types of human barriers impeding corridor connectivity. 2.2. For the WBRCs, identify and analyze non-road barriers (e.g., land uses) impacting corridor connectivity.
Intent #3: **Identify Wildlife Vehicle Conflicts Areas**	3.1. Improve and standardize road data collection methods for wildlife-vehicle conflicts (WVC) and wildlife carcasses. 3.2. Develop predictive models to identify site-specific road segments at higher risk of deer- and bear-vehicle collisions. 3.3. For the at-risk species and other species of interest (e.g., elk) that are identified through completing Action #1.1, identify wildlife crossing concern areas.
Intent #4: **Prioritize Wildlife Crossing Projects**	4.1. Areas of High WVC Occurrences: Further evaluation is required to identify specific sites where wildlife crossing enhancement projects are warranted and will be feasible. Considerations include the following: ▪ Develop methodology to identify specific road segments where wildlife crossings would be beneficial for driver safety. ▪ Develop a process to prioritize potential crossing projects from a driver safety perspective. 4.2. WBRCs: Further evaluation is required to identify specific areas within WBRCs that are priorities for land protection, habitat restoration, and/or wildlife crossings to support wildlife habitat corridor connectivity. 4.3. Nexus Areas: In addition to the above considerations for Actions #4.1 and #4.2, develop a process on how to prioritize wildlife crossing enhancement projects for limited funding opportunities.

Legislative Intent	Recommended Future Actions
Intent #4 continued from prior page	4.4. Step-down or companion plans, tiering from this Plan, will be necessary to fully address the habitat corridor and wildlife crossing needs for at-risk terrestrial and aquatic species and other species of interest (e.g., federally-protected species, state-protected species, SGCN, elk, small- to medium-sized mammals, amphibians, reptiles, and various bird species such as marsh birds). 4.5. Develop cost-benefit analyses and valuing of wildlife crossings. 4.6. Develop a framework for regional-level and local-level analyses and where efforts to establish targeted partnerships should be focused to identify project opportunities.
***Intent #5*: Provide a Public Data Portal**	5.1. To support planning for wildlife corridor connectivity at multiple spatial scales (e.g., state, regional, and local), develop a geospatial viewer application that is inclusive of relevant planning data that are spatially scalable.
***Intent #6:* Update Plan Every Four Years**	6.1. Establish state interagency and external coordination to ensure progress on updating and implementing this Plan. Initial tasks may include the following: ▪ Identify staffing and funding opportunities ▪ Prioritize the Recommended Future Actions ▪ Develop a timeline for which actions can be accomplished before the next Plan update ▪ Identify and establish working groups as needed, including a focus on timing of implementation and coordination with technical and subject matter expert groups

[1] Acronyms used in this table: AOP = aquatic organism passage; SGCN = Species of Greatest Conservation Need; VDCR = Virginia Department of Conservation and Recreation; VDOF = Virginia Department of Forestry; VDOT = Virginia Department of Transportation; VDWR = Virginia Department of Wildlife Resources; WBRC = Wildlife Biodiversity Resilience Corridor; WVC = wildlife-vehicle conflict

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Appendix A. Wildlife Corridor Action Plan Legislation

Code of Virginia
Title 29.1. Wildlife, Inland Fisheries and Boating
Chapter 5. Wildlife and Fish Laws

§ 29.1-578. Definitions
As used in this article, unless the context requires a different meaning:

"Human-caused barrier" means a road, culvert, fence, wall, commercial or residential development, or other human-made structure that has the potential to affect the natural movement of fish or wildlife across a landscape.

"Plan" means the Wildlife Corridor Action Plan established pursuant to this article.

"Wildlife corridor" means an area connecting fragmented wildlife habitats separated by human activities or infrastructure.

§ 29.1-579. Wildlife Corridor Action Plan; adoption
A. The Department [of Wildlife Resources], in collaboration with the Department of Transportation, the Department of Forestry, and the Department of Conservation and Recreation, shall create a Wildlife Corridor Action Plan.

B. The Plan shall:

1. Identify wildlife corridors, existing or planned barriers to movement along such corridors, and areas with a high risk of wildlife-vehicle collisions. The Plan shall list habitat that is identified as of high quality for priority species and ecosystem health; migration routes of native, game, and migratory species using the best available science and Department surveys, including landscape scale data from the ConserveVirginia database or a similar land conservation strategy database maintained by the Department of Conservation and Recreation; lands containing a high prevalence of existing human barriers, including roads, dams, power lines, and pipelines; areas identified as of high risk of wildlife-vehicle collisions; habitat identified by the Department as being occupied by rare or at-risk species; and habitat identified as Critical Habitat under the federal Endangered Species Act of 1973, P.L. 93-205, as amended.

2. Prioritize and recommend wildlife crossing projects intended to promote driver safety and wildlife connectivity. The Plan shall describe each such project and include descriptions of wildlife crossing infrastructure or other mitigation techniques recommended to meet Plan goals.

3. Contain maps utilizing the ConserveVirginia public portal, or a similar land conservation strategy public portal maintained by the Department of Conservation and Recreation, and other relevant state databases that detail high-priority areas for wildlife corridor infrastructure and any other information necessary to meet the goals of the Plan.

C. The Secretary of Natural Resources and the Secretary of Transportation shall jointly submit the Plan to the Chairs of the House Committee on Agriculture, Chesapeake and Natural Resources and the Senate Committee on Agriculture, Conservation and Natural Resources no later than September 1, 2022, and shall jointly submit an updated version of the Plan every four years thereafter.

D. The Department shall assist state agencies and political subdivisions, and by request any federal agency, in considering and incorporating, where applicable, wildlife corridors and the recommendations of the Plan when developing any governmental strategic plan, map, or action. The Department shall publish the plan and any subsequent updates on its website.

Appendix B. Wildlife Crossing Case Studies

Four case studies of current, planned, and proposed wildlife crossing sites in Virginia are described that represent existing or under development projects. These case studies are the following:

- Southwestern Virginia Elk and U.S. Route 121/U.S. Route 460 Transportation Project
- Southern Albemarle Mountains Wildlife Connectivity Project
- Fort Belvoir Wildlife Crossings
- Wildlife Crossing Opportunities near the Great Dismal Swamp National Wildlife Refuge

These case studies represent some of the first wildlife crossings that were installed or currently under design in Virginia. Lessons learned from these case studies will be leveraged for future state wildlife crossing efforts.

Case Study: Southwestern Virginia Elk and U.S. Route 121/VA 460 Transportation Project

Background

Elk along U.S. Route 121/VA Route 460 Corridor Q transportation project. (Braiden Quinlan/Virginia Tech)

A research study is underway in Virginia is addressing driver safety and habitat connectivity across a new highway. North American elk are known to occur along the 14.2-mile U.S. Route 121/VA 460 project area (also known as Poplar Creek Phase B or Corridor Q) in Buchanan County in southwestern Virginia. The driver safety risk from potential collisions with elk are apparent with Corridor Q, a portion of which has either been constructed, is presently under construction, or will soon be under construction.

Corridor Q intersects a Wildlife Biodiversity Resilience Corridor (as described in Chapter 3 of this Plan). In addition, According to VDCR's Natural Heritage Data Explorer (www.vanhde.org), the Route 121/460 Corridor Q project is within the Natural Lands Network; the area is categorized as having moderate to high ecological integrity and much of Corridor Q is located in a habitat ecosystem diversity area.

Because of the potential for risks to driver safety and impacts to the elk population within an area classified as a Wildlife Biodiversity Resilience Corridor, a collaborative research effort between VTRC (the research division of VDOT) and VDWR is currently underway to address these concerns. The purpose of the study is to: (1) determine suitable locations and designs for a series of wildlife crossing structures connected by fencing; (2) evaluate site-specific wildlife crossing and fencing construction costs and the crash reductions needed to offset those costs; and (3) determine the most suitable federal funding programs. While elk are the primary focus of the evaluation, minimizing wildlife crash risk and maintaining habitat connectivity would also benefit multiple wildlife species in the area.

Elk in Virginia

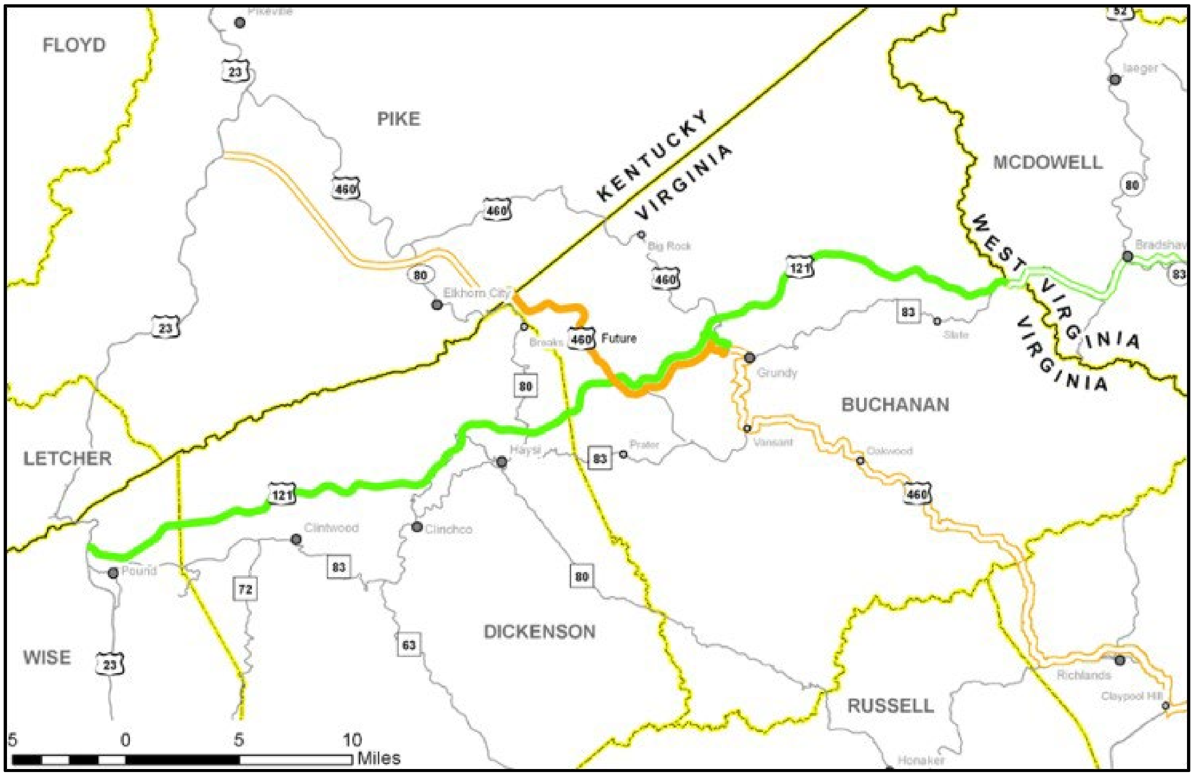
Historically, elk were found throughout the U.S., including Virginia. Elk were extirpated from the eastern U.S. by the late 1800s, as a result of unregulated market hunting and habitat loss. Elk habitat in Virginia primarily consists of mature tree stands and open lands created by the reclamation of former surface coal mines. These areas provide food resources and preferred habitat for not only the elk herd, but also various other wildlife species. During 1997 to 2002, more than 1,500 elk were reintroduced into eastern Kentucky, resulting in some elk moving over into Virginia. A growing interest in elk in Virginia prompted the development of a plan for elk restoration, and in 2009, the Board of Game and Inland Fisheries (now the Board of Wildlife Resources) directed VDWR to develop a plan to restore and manage a population of elk (Donaldson and Rosenberger 2022).

From 2012 to 2014, a total of 75 elk were relocated from southeastern Kentucky onto a reclaimed mine site in Buchanan County, Virginia. Currently, elk are managed in a designated Elk Management Zone largely spanning three counties: Buchanan, Dickenson, and Wise. By September 2020, Virginia's restored elk herd was estimated at more than 250 individuals (VDWR website https://dwr.virginia.gov/wildlife/elk/). For the first time since the restoration, VDWR started GPS-collaring elk in 2019 and has continued through 2023. Virginia Tech and VDWR initiated a research project in 2020 to use mark re-capture methods to determine elk population size, a significant portion of which overlaps with the Corridor Q project. Additional objectives of the research are to determine seasonal resource use and home ranges of elk that were collared during the restoration and in more recent years.

Corridor Q Transportation Project

Corridor Q of the Appalachian Development Highway System traverses portions of Kentucky, Virginia, and West Virginia, generally following the existing Route 460 corridor, with some sections on new locations off of existing Route 460. U.S. Route 121 is a new highway that would generally parallel the VA 83 corridor from U.S. Route 23 in the Town of Pound, Virginia to the West Virginia state line. In October 2010, the Appalachian Regional Commission approved the realignment of 13.1 miles of Corridor Q that follows Route 460 in Buchanan County between the Kentucky-Virginia state line and the Town of Grundy to coincide with (i.e., overlap or follow the same alignment as) the Route 460 Connector, Section IIIA of US Route 121, and a portion of Section IIIB of U.S. Route 121 (U.S. Route 121/Route 460 [Corridor Q] Section IIIB [Poplar Creek] - Phase B Environmental Assessment, September 20, 2021).

Within the region where elk reside, VDWR biologists have documented four elk-vehicle crashes prior to the 2012 elk reintroductions (these were elk from Kentucky that had moved into Virginia) and four crashes after the elk reintroductions. For Corridor Q, the abundance of high quality habitat for elk along and surrounding Corridor Q may present a risk to driver safety when the road opens to traffic. Elk are frequently seen grazing on the portions of the Corridor Q roadside that have been planted with grasses and forbs to control erosion during construction. Other factors that may influence elk-vehicle conflict risk include a high speed limit, lack of lighting, and undulating contours.



Route 121/460 Corridor Q Project, Regional Connectivity map. Colored lines: orange line = Corridor Q Project; green line = Under development Route 121.

Benefits to Local Economies

The newly established elk population has been an important draw to the area and elk-viewing tourism is becoming increasingly popular. Additionally, VDWR held its first elk hunt during October 2022 and expects elk hunting opportunities to increase as the elk population continues to grow. Tourists and hunters visiting Buchanan County positively contribute to the local economy through lodging, food, gasoline, and other local businesses. Buchanan County Tourism, Buchanan County Chamber of Commerce, and Southern Gap Outdoor Adventures feature elk in their logos, indicating the importance of the elk population to the area.

Corridor Q is being constructed as part of an initiative to promote economic development in underserved communities. This intended benefit of Corridor Q can be fully realized with the implementation of elk crash countermeasures, which are proven to reduce the risk of elk-related crashes while also providing elk and other wildlife a safe means of moving through the landscape. When designed and located properly, wildlife crossings, in conjunction with wildlife fencing, are the most consistently effective measure at reducing WVCs and maintaining habitat connectivity across a road.

Identifying Opportunities to Improve Driver Safety and Maintain Habitat Connectivity

As stated above, a research study is underway between VTRC and VDWR to identify suitable locations and designs for wildlife crossing structures and associated fencing to reduce risks to driver safety and improve elk habitat connectivity along Corridor Q (which would also maintain the habitat connectivity of the Wildlife Biodiversity Resilience Corridor that Corridor Q intersects). To identify suitable structure locations, road segments along the corridor will be evaluated based on elk distribution and habitat use (determined from GPS data from collared female elk), terrain, land ownership, and human activity. The study will also include a detailed cost-benefit analysis to compare the costs of wildlife crossings with the expected savings from prevented crashes with elk and deer (Donaldson and Rosenberger 2022).

In addition, the Virginia Tech Transportation Institute is evaluating the feasibility of the supplemental use of animal detection driver warning systems along Corridor Q. Animal detection driver warning systems are designed to sense large animals along the roadway and warn drivers about their presence. Some studies have demonstrated high wildlife crash reduction rates with the strategic use of these systems at discrete crash hotspots and at fence ends. Animal detection systems typically include above-ground area-cover sensors, break-the-beam sensors, or thermal detectors that are installed along the roadside to detect wildlife as they approach the pavement. Once detection is verified, a warning system (such as a flashing warning sign or a changeable message sign that wirelessly communicates with the detection cable) can be used to alert drivers to the danger. Any resulting reductions in vehicle speed (and associated reductions in stopping distance) decreases the risk of a collision (Donaldson and Rosenberger 2022). Because VDOT currently considers these systems experimental, any installation of these systems would be evaluated as pilot applications.

Typical message sign connected to an animal detection system to warn drivers of elk along the road. (komonews)

As part of the research study, the research team is identifying federal funding programs for which the prioritized solutions may be eligible under the Infrastructure Investment and Jobs Act. These include, but are not limited to, the following programs:

- Wildlife Crossing Pilot Program
- Surface Transportation Block Grant Program
- Bridge Investment Program
- Nationally Significant Freight & Highway Program (INFRA)
- Federal Lands, Federal Lands Access, and Tribal Transportation Programs
- Highway Safety Improvement Program
- Transportation Alternatives Program

In the event that wildlife crossing construction is pursued, a parallel effort has been initiated to coordinate stakeholder involvement for the purpose of gathering support for federal funding applications. The list of stakeholders can be viewed at: https://vswcc.weebly.com/elkandcorridorq.html.

In conclusion, this case study demonstrates a clear nexus between driver safety objectives, management of a newly established elk population, and preserving the conservation value of a Wildlife Biodiversity Resilience Corridor. Engaging key partners and stakeholders will be integral in increasing the likelihood of successful implementation.

Elk along Corridor Q project. (Braiden Quinlan/Virginia Tech)

Case Study: Southern Albemarle Mountains Wildlife Connectivity Project

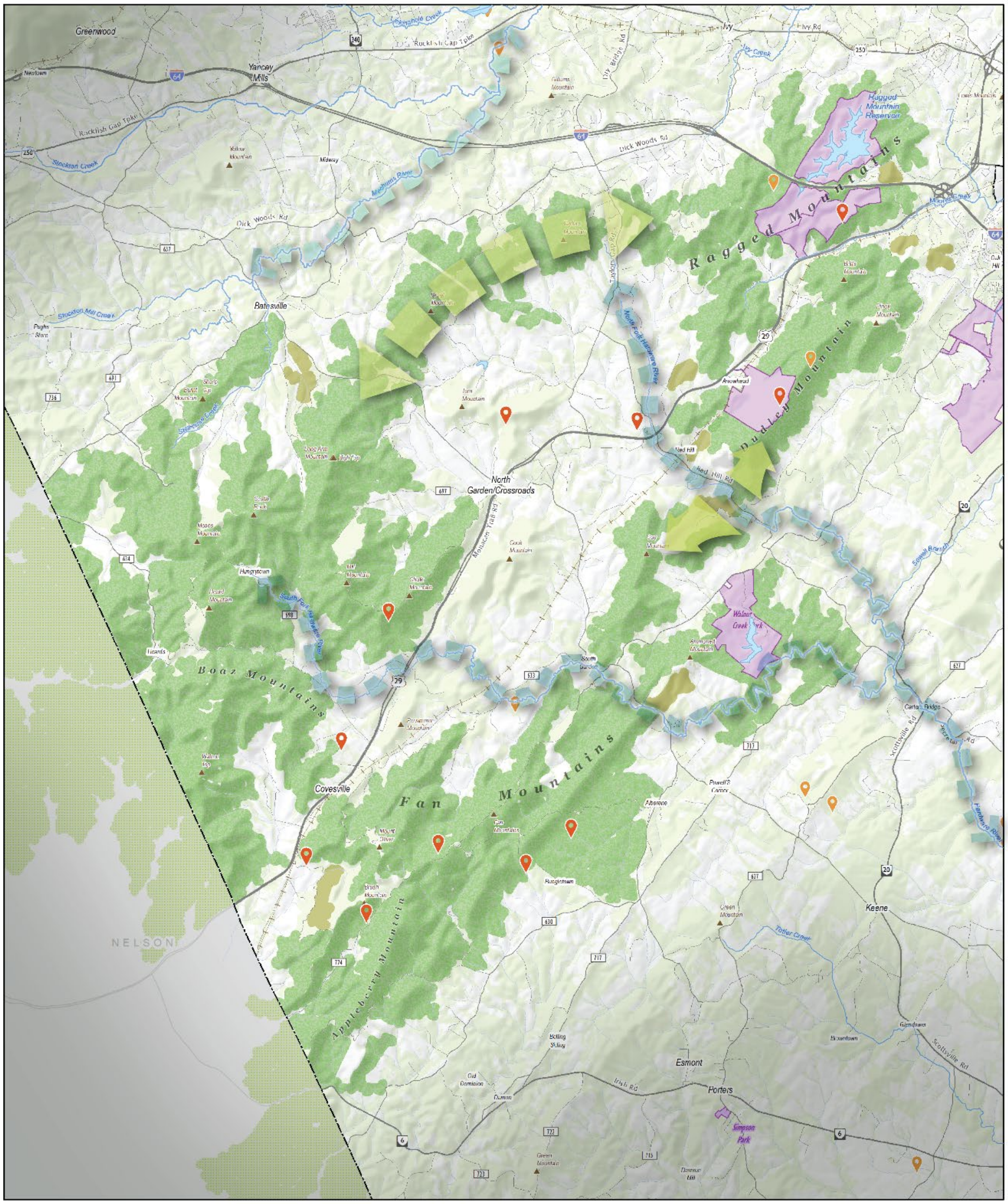
Background

The Southern Albemarle Mountains in Albemarle County have large, intact forest blocks with high ecological integrity and are identified as a Conservation Focus Area in the county's Biodiversity Action Plan (BAP, Albemarle County 2018). Route 29 south of Charlottesville bisects this area and was identified in the BAP as a likely barrier to wildlife movement. County staff and the VTRC have been studying several underpasses (bridges and culverts) to assess their current usage by wildlife and to identify potential enhancements that may improve connectivity and facilitate the movement of wildlife through these structures, benefitting both wildlife and driver safety, known as the Southern Albemarle Mountains Wildlife Connectivity Project. This case study serves as an example that demonstrates the potential benefits of early communication efforts and partnering between VDOT and a municipality to determine potential wildlife enhancements based on the evaluation of existing underpasses. The case study also serves as an example of how a local city or county municipality may be able to use the *Wildlife Corridor Action Plan* as a planning tool within their own long-range, comprehensive planning process.

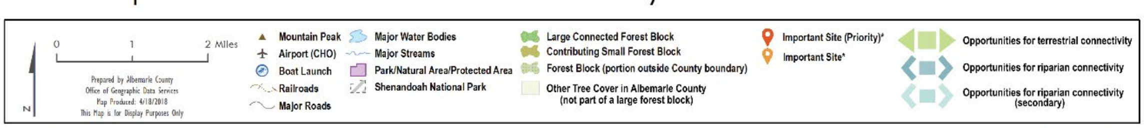
Albemarle County's Biodiversity Action Plan is the most recent milestone in a long history of the county's commitment to protecting natural resources and biological diversity. The BAP was completed in June of 2018, and a goal related to its implementation has since been incorporated into Albemarle County's Comprehensive Plan. The BAP includes extensive spatial analyses aimed at identifying priority resource protection areas and opportunities for landscape connectivity, to help inform recommendations for natural resource management and protection. The spatial analysis identified three primary Conservation Focus Areas within the county, one of which is the Southern Albemarle Mountains. The analysis identified the Hardware River, which lies within the Southern Albemarle Mountains, as an important connectivity opportunity.

Goal 1 and Goal 5 of the BAP specifically address the importance of preserving habitat connectivity and important wildlife habitat linkages in the County:

- GOAL 1: Recognize the importance of the three Conservation Focus Areas. Prioritize conservation of the land and resources within them and, where possible, connections among them.
- GOAL 5: Minimize or reduce habitat fragmentation county-wide and maintain habitat connectivity.



Map 9: Potential Conservation and Habitat Connectivity in the Southern Albemarle Mountains



Map 9 illustrates the potential for conserving and establishing connectivity among habitat areas in the Southern Albemarle Mountains and beyond. Arrows indicate existing or potential connectivity among habitat areas.

* The markers for Important Sites do not represent the exact center or extent of the site, but rather the general location of the site.

Southern Albemarle Mountains GIS connectivity analysis done to identify important connectivity sites. Arrows indicate existing or potential connectivity among habitat areas (Albemarle County Biodiversity Action Plan 2018).

Specifically, the BAP also identifies a recommendation to "investigate a Route 29 underpass in southern Albemarle County to better connect eastern and western portions of the Southern Albemarle Mountains Important Site, a conservation priority area." This recommendation was, in part, the impetus for the development of the Southern Albemarle Mountains Wildlife Connectivity Project.

Since February 2021, the County's Natural Resource Program has been collecting wildlife data using trail cameras to identify the type of wildlife using underpasses and frequency of successful crossings under Route 29. Five underpasses have been regularly monitored with cameras using similar monitoring methods performed for the I-64 underpass and wildlife fencing study due to the success of that fencing project. The I-64 underpass and wildlife fencing study used trail cameras to determine wildlife use of two existing structures. Wildlife activity was monitored at the underpasses and along the roadside both before and after the installation of wildlife fencing to guide wildlife to the structures and prevent them from crossing the highway. The I-64 wildlife fencing resulted in an average deer crash reduction of 92% and an increase in wildlife use of the structures of up to 400%.

After initial site assessment and data collection for the Southern Albemarle Mountains Wildlife Connectivity Project, the County Natural Resources Program is focusing on three (3) priority underpasses along Route 29 that may have opportunities for future wildlife connectivity enhancements:

1. North Fork Hardware River - Bridge
2. South Fork Hardware River – Triple concrete box culvert
3. Cove Creek – Double concrete box culvert

A second part of the project has involved recruiting and training citizen scientists through the local chapter of Virginia Master Naturalists to help collect animal carcass data along this stretch of Route 29. Although police reports and anecdotal data have shown a high incidence of wildlife-vehicle collisions along this roadway over the years, the frequency and specific location of collisions is still largely unknown. Identification of these wildlife-vehicle collision "hotspots" may help inform the Southern Albemarle Mountains Wildlife Connectivity Project by identifying which of the monitored underpasses may be a higher priority for future implementation of connectivity enhancements. Since September of 2021, the volunteers have been piloting the use of Roadkill Observation and Data System field application and data dashboard customization (from the Center for Large Landscapes Conservation) for its potential utility on a broader scale in Virginia.

North Fork Hardware River Bridge, doe and fawn using bridge path. (Albemarle County)

South Fork Hardware River box culvert, bobcat. (Albemarle County)

Two bucks using the Cove Creek double box culvert. (Albemarle County)

Cove Creek double box culvert, coyote. (Albemarle County)

Based on preliminary results from the camera monitoring, several potential wildlife enhancements have been identified for the three culvert and bridge structures listed above including, but not limited to:

- Contour the slope beneath the bridge to create a functional trail for wildlife use. This would create a more well-established and functional path for wildlife under the bridge.
- Improve the access for wildlife at the entrances of the bridge and culverts by targeted vegetation and debris removal.
- Add directional wildlife fencing to one or more of the existing structures.
- Remove sediment within structures, which will increase structure height and encourage wildlife use.
- Consider feasibility for future structure replacement.
- Install interior structure lighting to encourage wildlife use.

County staff have begun initial outreach and coordination efforts with the VDOT Culpeper District and Charlottesville Residency, which oversee road and structure maintenance along this section of Route 29, to discuss the potential for wildlife enhancement opportunities. Identifying and connecting key stakeholders early in the planning process could identify early project integration opportunities, potential site design constraints, and better leverage of funding for future wildlife crossing enhancements such as large animal crash reduction measures.

Case Study: Fort Belvoir Wildlife Crossings—First in Virginia

Background

In 1995, the U.S. Army installed the first wildlife crossings in Virginia at Fort Belvoir in Fairfax County to mitigate concerns over wildlife-vehicle conflict and diminished wildlife movement across roads. At a cost of approximately $1 million, Fort Belvoir constructed two box culverts specifically designed for large- to medium-sized wildlife species to cross roads safely, incorporating critical design features such as natural lighting (grate skylight between lanes) and natural substrate. Both structures, on the Fairfax County Parkway, connected sensitive natural areas in the county between Huntley Meadows Park and Accotink Bay Wildlife Refuge (part of Fort Belvoir). This case study of the first wildlife crossing project in Virginia can help inform future wildlife crossing infrastructure needs in urban landscapes.

On Fairfax County Parkway, the larger box culvert is located just to the northwest of John J Kingman Road. It is 20 feet wide, 15 feet tall, and 192 feet long with an open bottom and a small stream running through it. The second culvert on this parkway is approximately 0.25 miles to the east of the first one. It is 10 feet wide, 6 feet tall, and 105 feet long with a concrete bottom. Both culverts include a metal grate in the ceiling that spans the median between the roads above, to allow in natural light. Fencing at both sites is minimal (approximately 100 feet) or non-existent.

Wildlife crossing underpasses installed along Fairfax County Parkway by Fort Belvoir. This larger box culvert on the parkway is near John J Kingman Road; Right: The smaller box culvert on the parkway is approximately 0.25 miles to the east of the larger one.

Effectiveness of the Fort Belvoir Wildlife Crossings

Deer exiting a culvert.

VTRC and the Army conducted two separate studies to assess the effectiveness of these two underpasses as wildlife crossings (Donaldson 2005; U.S. Army 2016). The VTRC study (Donaldson 2005) and Army study (U.S. Army 2016) used camera monitoring to document wildlife use during two time periods that were approximately 10 years apart. Both studies verified that deer were using the larger box culvert with high frequency. In total, 15 wildlife species utilized this larger underpass, including various birds, coyotes (*Canis latrans*), red foxes (*Vulpes vulpes*), groundhogs (*Marmota monax*), opossums (*Didelphis virginiana*), raccoon (*Procyon lotor*), and gray squirrel (*Sciurus carolinensis*) (Donaldson 2005; U.S. Army 2016). For the smaller culvert, deer were infrequently detected as using this underpass, though medium-sized wildlife such as raccoons were frequently photographed traversing it (Donaldson 2005); in total, 10 species used this culvert (U.S. Army 2016).

Great blue heron entering a culvert.

These studies demonstrate strong evidence for the use of well-designed wildlife crossings. The VTRC report concluded structures that are properly sized and located receive heavy use by wildlife, thus reducing potential wildlife-vehicle conflict. Underpasses with 12 feet or greater in height were best at facilitating deer passage, though that metric alone is not enough to contribute to the success of a structure. Donaldson (2005) also recommended that an openness factor of minimally 0.25 (see Donaldson 2005 for how this metric is calculated) may be required to promote wildlife use of these types of underpasses.

Conclusions

From 1995 to 2004 (the culverts were installed in 1995), there were only five documented deer-vehicle collisions centered within a 2.5-mile road segment where the culverts of this case study are located (source: Virginia's Highway Traffic Records Information System and Fairfax County police records). Fencing is minimal, or absent, along the roads adjacent to both culverts. Since research suggests fencing extending from underpass openings greatly reduces wildlife-vehicle conflicts along roadways (Transportation Research Board 2002; Hedlund 2003; Donaldson 2005; and McCollester 2009), installation of roadside fencing to funnel wildlife to these culverts may also assist in reducing WVCs.

In comparing the larger culvert to the smaller culvert, there may be room for improvement in future designs for similar structures. The difference in substrates (larger culvert had a natural stream bed and vegetated dry substrate and the smaller culvert had a concrete bottom) may have played a role in how a greater number of animals and diversity of species utilized the larger culvert; substrate condition also was a factor suggested by the Transportation Research Board (2002) as an important consideration for wildlife crossings. In addition, Donaldson (2005) implicated that the height and openness of underpasses such as box culverts may play a role in individuals and species utilizing these types of wildlife crossings.

This case study highlights the need to connect patches of habitat with wildlife crossings specifically designed for a number of targeted species, to not only reduce wildlife-vehicle conflicts, but also enhance the local ecology. As more observational data becomes available through new and continued research, there is likely room for improvements to these existing structures.

Case Study: Wildlife Crossings near the Great Dismal Swamp National Wildlife Refuge

Project Description

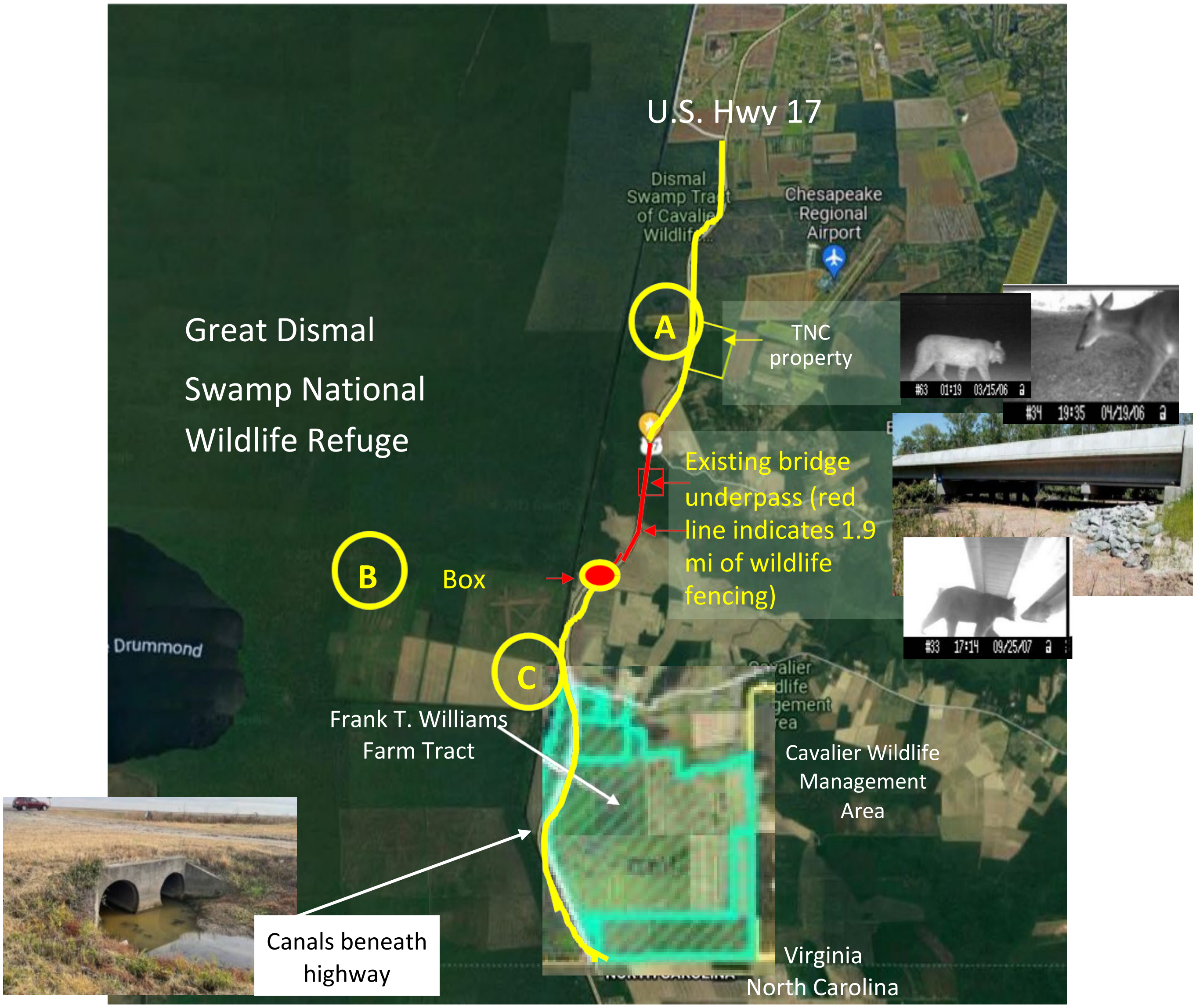
The Great Dismal Swamp National Wildlife Refuge (GDSNWR) is a 111,000-acre refuge that is home to a variety of wildlife. It includes one of the largest black bear populations on the U.S. East Coast and harbors 40 other species of mammals, 59 species of reptiles and amphibians, and more than 200 species of birds, many of which are uncommon or rare throughout Virginia. U.S. Highway 17 crosses the paleochannel (ancient water channel that has been filled with younger sediment) of the Northwest River, which consists of a riparian corridor that extends southeast from the GDSNWR. This riparian corridor contains wetland habitat (a swamp and saturated wetlands) that holds significant value in terms of its hydrologic functions and its plant and wildlife populations.

Throughout the planning and design of U.S. 17, VDOT coordinated with the U.S. Army Corps of Engineers, the U.S. Fish and Wildlife Service, and technical experts in the region to design measures to minimize impacts to the area’s natural resources. Measures included the construction of a vehicular bridge that measures 984 feet long, 81 feet across, and approximately 8 feet high. The primary purpose of the bridge was to span a wetland in the riparian corridor, but the project also included the construction of earthen berms beneath the far ends of the bridges to provide areas of dry crossing for wildlife. These berms were primarily intended for black bears that travel to and from GDSNWR. Vegetation was also planted up to the underpass entrances to encourage wildlife use. The Virginia Department of Transportation constructed 1.9 miles of 10-foot-high wildlife fencing that tie into the bridge underpass to encourage wildlife use. Nearly 1.5 miles of this fencing extends south of the bridge.

Further Opportunities to Reduce Risks to Driver Safety and Connect Wildlife Habitat

A camera monitoring study (Donaldson and Schaus 2009) found that the existing bridge underpass is very successful at facilitating passage by a dozen terrestrial species, including black bear and deer. However, there continue to be regular collisions with these species along the sections of unmitigated highway that border the GDSNWR. The 10-mile segment of U.S. Highway 17 in the map below (highlighted in yellow) represents additional potential wildlife crossing project areas. Any wildlife crossings in this area would help connect the GDSNWR to other patches of habitat for wildlife (including black bear) along the eastern coast of Virginia and North Carolina.

The following describes areas marked A, B, and C in the map below. To determine more precise locations of and costs for wildlife crossing projects within the highlighted road segments, further scoping is required.

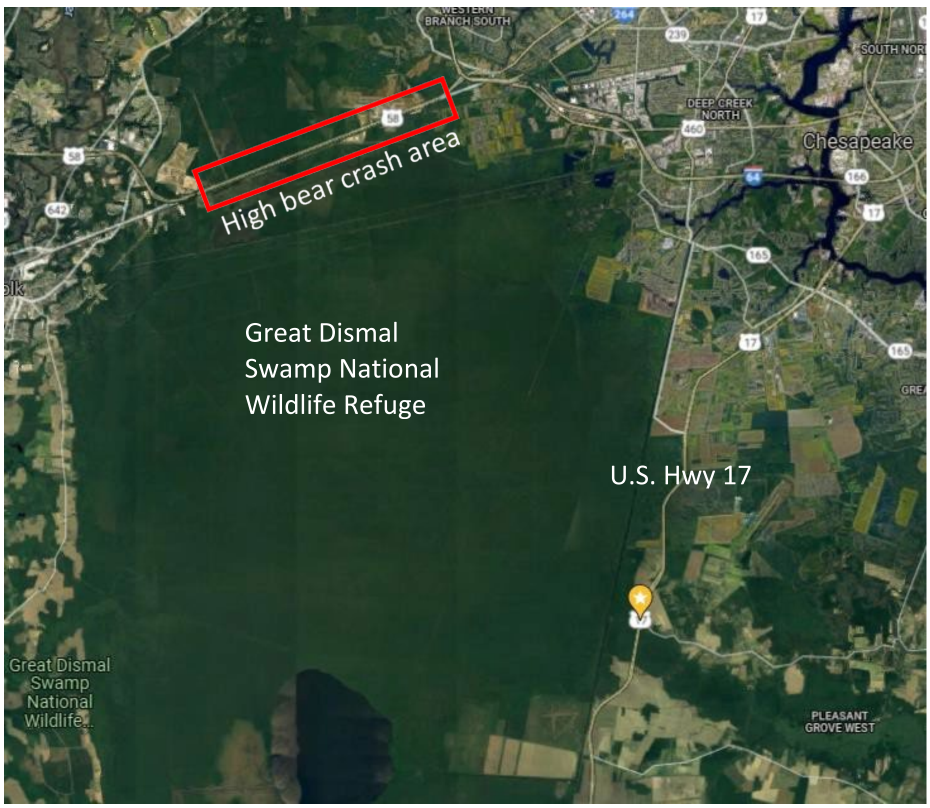


A: North of existing wildlife crossing. This road segment borders GDSNWR and the Bear Garden Wildlife Conservation Site (indicated in the map as "Dismal Swamp Tract of Cavalier Wildlife Management Area" but recently renamed as the Bear Garden Wildlife Conservation Site). There are regular wildlife crashes with deer and black bear along this road section.

B: Existing double box culvert. This is the location of an existing double box culvert 1.8 miles south of the wildlife crossing. The culvert openings are 10 feet by 6 feet, and the structure extends 197 feet in length. The culvert is partially filled with water. A monitoring study verified that the structure is unusable by most terrestrial wildlife species, and the dimensions are unlikely to be large enough to accommodate deer and bear (Donaldson and Schaus 2009). However, the fencing from the existing wildlife crossing extends to this culvert, and if this existing structure is replaced with a larger structure, it can be designed to facilitate both water and wildlife passage.

C: **South of existing wildlife crossing**. Most of this road segment is adjacent to a property that is characterized by the locality as a Unique Economic Development Opportunity Area. This area lies between the GDSNWR and the Cavalier Wildlife Management Area (VDWR). A wildlife crossing in this area is an ideal location to facilitate wildlife movement between the GDSNWR and high quality habitat areas to the east and southeast of U.S. 17. Small canals extend beneath U.S. 17 along this road segment and may provide opportunities for enlarging the existing small drainage culverts for the dual purpose of facilitating water and wildlife passage.

As a potential wildlife crossing alternative to the above recommendations, another area may be along U.S. 58, a high bear crash area that cuts through the northern end of the Great Dismal Swamp NWR (illustrated below).



Appendix C. Virginia Natural Lands Assessment Ecological Integrity Prioritization Variables

Most Important Habitats
This field contains the total area of intersection between each Ecological Core or Habitat Fragment and important habitats for imperiled species and Species of Greatest Conservation Need as identified by the North Atlantic Landscape Conservation Cooperative, of which the Virginia Department of Wildlife Resources was a member.

Variety of Unmodified Wetlands
This field contains the variety of unmodified wetlands per Ecological Core or Habitat Fragment. Unmodified wetlands were based on USFWS National Wetlands Inventory data from which farmed, diked, ditched, and otherwise modified wetlands were removed. Beaver impoundments, which are a natural form of modification, were left in the unmodified wetlands layer.

Topographic Relief Index
This field contains the standard deviation of elevation values from 1-arc second, USGS Digital Elevation Models per Ecological Core or Habitat Fragment.

Anthropogenic Isolation Index
This field contains a measure of anthropogenic core isolation, which was calculated by dividing the proximity zone of each Ecological Core or Habitat Fragment by its area. Open water was not used as an isolation feature for this variable.

Length of Streams in Interior Forest
This field contains the total length of streams within interior forest per Ecological Core or Habitat Fragment. High-resolution flow lines from the USGS National Hydrography Dataset were used for the streams data source.

Total Area
This field contains the total area of each Ecological Core or Habitat Fragment in square meters.

Maximum Depth
This field contains the maximum depth of each Ecological Core or Habitat Fragment. This value represents the maximum distance (meters) to the deepest part of the feature measured from all edges.

Conservation Site Biodiversity Rank Index
This field contains the Conservation Site Biodiversity Rank Index value for each Ecological Core or Habitat Fragment. The index was developed by summing the products of biodiversity rank factors and biodiversity rank weights for each feature. The biodiversity rank factors resulted from dividing conservation site intersections with each feature by the total area of the intersecting conservation sites with the same biodiversity rank. The biodiversity rank weights were 50, 40, 30, 20, and 10 for B1, B2, B3, B4, and B5 ranked conservation sites, respectively. The Conservation Sites dataset was developed by the Department of Conservation and Recreation, Division of Natural Heritage.

Steam Conservation Units and Threatened and Endangered Waters Index

This field contains the Stream Conservation Units (SCU) and Threatened and Endangered (T&E) Waters Index value for each Ecological Core or Habitat Fragment. The index was developed by summing the products of biodiversity rank factors and biodiversity rank weights for each feature. The T&E Waters were buffered to the same width (5 meters) as SCUs and assigned biodiversity ranks before they were merged. The biodiversity rank factors resulted from dividing T&E-SCU waterway intersections with each feature by the total area of the intersecting T&E-SCU waterway with the same biodiversity rank. The biodiversity rank weights were 50, 40, 30, 20, and 10 for B1, B2, B3, B4, and B5 ranked conservation sites, respectively. The T&E Waters dataset was developed by the Department of Wildlife Resources. The SCU dataset was developed by the Department of Conservation and Recreation, Division of Natural Heritage.

Appendix D. Wildlife Crossing Concern Areas

The high risk WVC areas and Nexus Areas presented in Chapter 4 are associated with statewide WVC data that are most relevant for large mammals, in particular for white-tailed deer and black bear; thus, these areas likely are not fully representative of significant WVC impacts on habitat connectivity for smaller terrestrial wildlife species and aquatic organisms, including Species of Greatest Conservation Need (SGCN) identified in Virginia's Wildlife Action Plan. Due to these inherent limitations of the statewide WVC datasets, VDWR SMEs identified several road-associated sites for some federally and state-listed species and SGCN. These sites are termed Wildlife Crossing Concern Areas (WCCA) and are potentially experiencing road-based wildlife mortality at a level that may be causing detrimental population impacts to specific wildlife species or taxonomic groups. These WCCAs are described in the table below. Although only six sites are described in this table, it is probable that other WCCAs exist throughout the state. Further study is required to identify the location of additional WCCAs.

Since limited or no WVC data exist for WCCAs, further study is required to determine whether the associated roads are problematic from a driver safety perspective and/or for wildlife habitat connectivity, and if so, to then identify potential wildlife crossing opportunities.

Wildlife Crossing Concern Areas identified by VDWR subject matter experts.

Concern Area General Location	Species or Taxonomic Group	Associated Road(s)	Description
Accomack County, Eastern Shore	Birds and Reptiles	Chincoteague Causeway; Saxis Wildlife Management Area Road	Subject matter experts from the Virginia Department of Wildlife Resources routinely observe wildlife carcasses along these two roads. The Chincoteague Causeway and Saxis WMA Road traverse within/along important saltmarsh habitats on the Eastern Shore that are rich with biodiversity, such as a variety of waterbirds (seabirds, rails, wading birds, and shorebirds), reptiles (e.g., diamondback terrapin [*Malaclemys terrapin terrapin*; Tier IIa SGCN[1]]), and migratory and resident passerines. These saltmarshes provide critical breeding and non-breeding habitat for these species, encompass essential fish habitat, and support a robust shellfish industry in the region.
South of Virginia Beach	Reptiles and Amphibians	Pungo Ferry Road; Indian River Road	These roads bisect significant wetland habitats and VDWR SMEs frequently observe numerous roadkill of reptiles and amphibians. These animals frequently move between the wetland habitat patches fragmented by these two roads as the animals traverse

Concern Area General Location	Species or Taxonomic Group	Associated Road(s)	Description
			across the larger complex of natural habitats in this region. In addition, reptiles also are attracted to these roads to bask in the sunlight for thermoregulation.
Augusta and Nelson Counties, Afton Mountain	Allegheny Woodrat	Interstate 64	Interstate 64 across Afton Mountain fragments habitat for a population of the Allegheny woodrat (*Neotoma magister*), a Tier IVa SGCN. This habitat fragmentation is resulting in a population break (and a genetic flow impedance) between woodrats north and south of I-64 on Afton Mountain.
Wise and Scott Counties	Yellow-Spotted Woodland Salamander	Route 619 (Wise and Scott Counties); Route 630 (Wise County)	The yellow-spotted woodland salamander (*Plethodon pauleyi*) is a newly described species known to inhabit sandstone and forest habitats in known roadside areas. Some occupied locations are no more than 5-6 feet from the road edge. Subject matter experts from the Virginia Department of Wildlife Resources state that further study is necessary to understand whether WVCs may be detrimentally impacting this species.
City of Newport News and Yorktown	Amphibians and Reptiles	Fort Eustis Boulevard/Route 105	Fort Eustis Boulevard (Route 105) in Newport News/Yorktown bisects a significant Coastal Plain pond complex (vernal pools) and is a known barrier to movement between available and occupied state threatened Mabee's salamander (*Ambystoma mabeei*) breeding ponds. It may be a likely movement barrier for other species of conservation concern, e.g., spotted turtle (*Clemmys guttata*; Tier IIIa SGCN) and Eastern box turtle (*Terrapene carolina carolina*; Tier IIIa SGCN).
Tennessee River Basin	Aquatic SGCN[1]	Roads within/adjacent to Critical Habitat designation	The Tennessee River Basin is one of the most biologically diverse watersheds in North America and is home to at least 270 species of fish and over 100 species of freshwater mussels. In Virginia, this basin includes the Powell River, Clinch River, and Forks of the Holston (North, Middle, and South) River. These waters are known to support numerous federal- and state-listed mussels, representing some of Virginia's most imperiled species and overlain by federal Critical Habitat designation. As such, the Tennessee River Basin is the target of several conservation efforts supported by the VDWR, the USFWS, and other conservation partners. It is important to acknowledge the unique nature of this system and to ensure that wildlife passage, particularly aquatic organism passage, is a consideration of any road infrastructure plans in this region.

[1] SGCN = Species of Greatest Conservation Need as identified within the Virginia Wildlife Action Plan; SGCN Tiers I-IV are not a legal status (Tier levels are defined here); SGCN Conservation Opportunity Rankings (a, b, c) are also not a legal status (Ranks are defined here).