Washington Habitat Connectivity Action Plan (WAHCAP)

Contents

Executive Summary

Habitat connectivity is critical to maintaining Washington's biodiversity, ecosystem resilience, and climate adaptation potential. As landscapes become increasingly fragmented due to transportation infrastructure, urban expansion, and land-use changes, wildlife populations face growing barriers to movement, increasing risks of genetic isolation, habitat loss, population extirpation, and wildlife-vehicle collisions.

The Washington Habitat Connectivity Action Plan (WAHCAP) builds upon Washington's leadership in connectivity science, synthesizing decades of research to establish clear priorities for on-the-ground projects that will protect and reconnect Washington's landscapes for wildlife. This Action Plan identifies both transportation and landscape-level terrestrial connectivity priorities, ensuring that Washington's approach to connectivity conservation is comprehensive and implementation-focused.

Washington State's Connectivity Vision – A Network of Connected Landscapes

Habitat connectivity refers to the degree to wildlife can move across the landscape as needed to support resilient ecological processes and population dynamics. Connected habitats are critical for wildlife to find food and shelter, migrate seasonally, establish new territories, and maintain healthy populations through genetic exchange. Connectivity also supports broader ecological functions such as seed dispersal and pollination and sustains species important to cultural traditions such as hunting and gathering.

As climate change continues to shift habitats and environmental conditions, maintaining connected landscapes becomes even more important to allow species to adapt and persist. However, habitat connectivity in Washington is increasingly threatened by population growth, transportation and energy infrastructure, and expanding development. Balancing human needs with the protection of ecological processes is essential. Protected areas managed to support biodiversity and ecosystem functions as well as working lands, such as sustainably managed farms and forests, play a key role in supporting habitat connectivity across the state.

Broad Corridors and Major Linkages: The Washington Habitat Connectivity Action plan (WAHCAP) identifies 12 Connected Landscapes of Statewide Significance (CLOSS) that provide the foundation for understanding and maintaining large-scale ecological connectivity across the major ecological regions of Washington (Figure 1). The Connected Landscapes are broad conceptual pathways, not precise routes, that help visualize large-scale goals for connectivity including identifying barriers and linkages critical to supporting a statewide connectivity network. Additional analysis in WAHCAP further identifies critical elements within these connected landscapes including large and relatively intact habitat core areas, habitat corridors or pathways facilitating movement between core areas, and fracture zones created by major highways and other development that restrict or impede wildlife movement in crucial locations throughout the state.

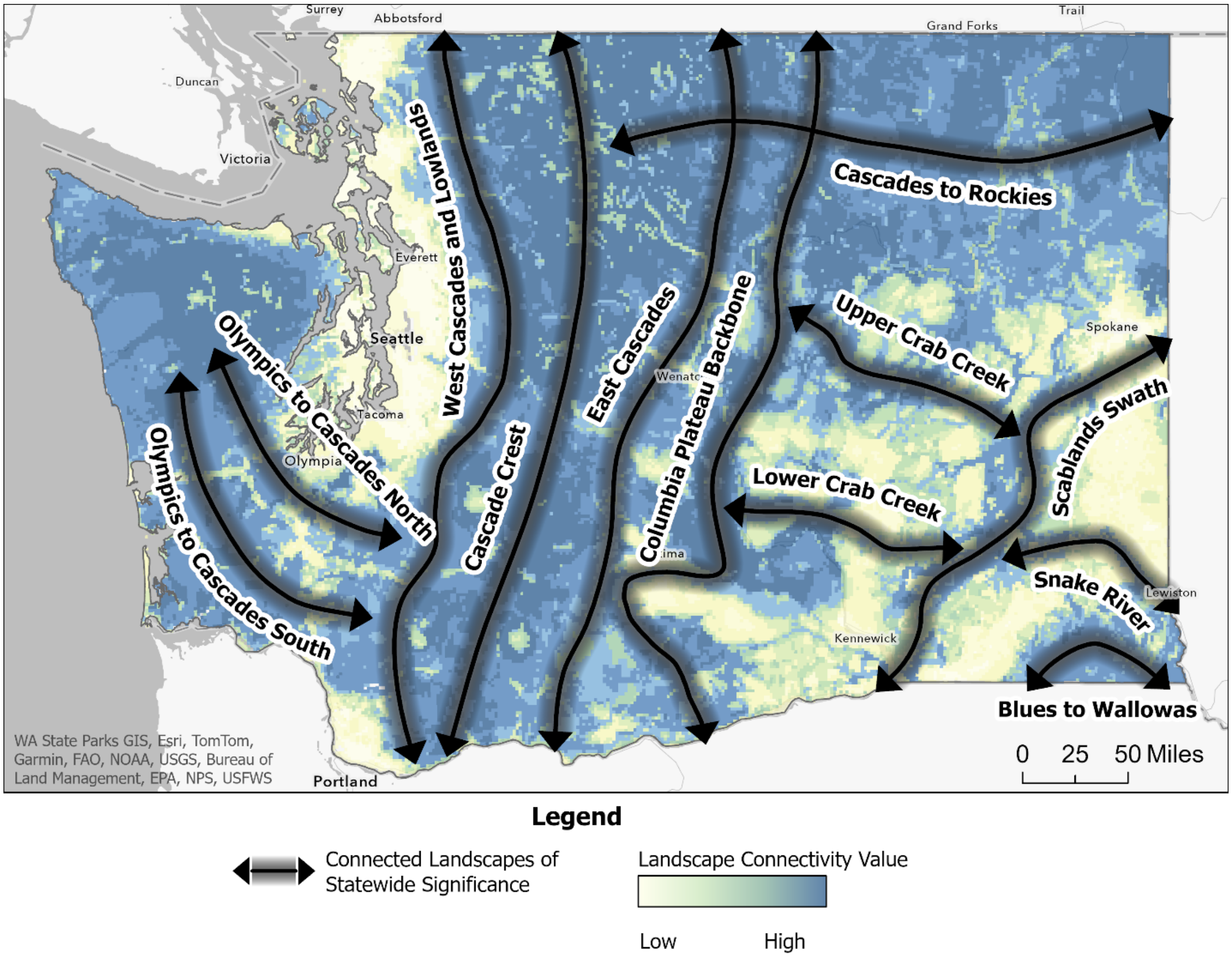

Figure 1. WAHCAP's 12 Connected Landscapes of Statewide Significance (CLOSS)—shown with black arrows—that link Washington's major ecological regions, including the Olympic Peninsula, Willapa Hills, Cascade Mountains, Rocky Mountains, Blue Mountains, and the Columbia Platea.

The CLOSS network was developed using spatial data depicting multiple landscape connectivity values, highlighting the most critical areas connecting key ecosystems and regions to support resilient connectivity functions and values across Washington. These broad pathways connect the Olympic Peninsula, Willapa Hills, Cascade Mountains, Northern Rockies, Blue Mountains, and shrubsteppe on the Columbia Plateau.

Statewide Transportation and Landscape Connectivity Priorities:

A primary goal of this plan was to identify priority locations for connectivity conservation action at the statewide scale. Our analysis identified a Long List and a more selective Short List of discrete locations on state highways that are high statewide priorities for road barrier mitigation to facilitate safe passage for wildlife and reduce wildlife-vehicle collisions. These transportation priorities and the landscapes they connect are priority locations for connectivity conservation in Washington State.

Beyond the transportation priorities, WAHCAP provides a framework for prioritizing landscape connectivity to support broad-scale ecological connectivity across Washington's diverse ecosystems. The framework identifies four primary criteria and associated data to support decision-making:

1. Landscape connectivity functions and values

WAHCAP provides data on 10 key elements of connectivity functions and values in Washington State including metrics representing structural ecosystem connectivity, network importance, landscape permeability, species of greatest conservation need hot spots, potential to support functional connectivity based on focal species analysis, climate connectivity, and consistency with pre-existing landscape conservation priorities.

A synthesized layer of connectivity functions and values incorporates these 10 elements allowing for broad-scale identification of key connectivity areas in the state. We used this synthesized data layer to identify transportation priority locations where barrier mitigation would most improve statewide ecological connectivity. We also used cluster analysis to identify landscape connectivity hot spots, or locations with a high-density of multiple connectivity functions and values.

2. Network importance at a statewide scale

We used the underlying landscape connectivity values data and maps to identify Connected Landscapes at the statewide and regional scales. These Connected Landscapes visualize big-picture connectivity goals for the state, providing a "road map" to ensure connected pathways are maintained for wildlife among all the major ecological regions of the state.

3. Protection status and management intent

Protected areas that are actively managed to sustain ecological functions and values form the backbone of a sustainable habitat connectivity network. Existing land protection status and management have significant implications for the feasibility of conservation actions and types of strategies needed at a given location. Public ownership and current management for ecological functions and values alone do *not* equate to permanent or consistently effective ecological protection. The conservation value of public lands depends on their underlying management mandates, land use allowances, and operational frameworks. Ensuring that public lands management includes and implements actions to support a connected network of ecologically resilient lands is essential to maintaining habitat connectivity in Washington State.

4. Habitat conversion threat

Our final prioritization criterion focuses on quantifying habitat conversion pressure – or how vulnerable the location in question is to loss. Threats to habitat loss, fragmentation, and conversion can occur on either public or private lands and can stem from a wide variety of sources. Through webinar and workshop discussions, we identified the following key threats to habitat connectivity:

1. Transportation barriers.
2. Residential and commercial development.
3. Wind and solar energy development.
4. Recreation.

WAHCAP provides a detailed analysis of transportation barriers and identifies priority locations for road barrier mitigation activities. We were able to develop or identify data layers representing development pressure from residential and commercial development and locations identified as suitable for solar development. We identified a need for the development of recreational impacts data based on trail and campground *use* as a critical next step for evaluating threats to and pressure on some of Washington's most valuable public lands and wilderness areas. The State and Tribal Recreation Impacts Initiative (STRII) was convened to better characterize the severity and distribution of recreation impacts to inform recreation management decisions.

WAHCAP's landscape and transportation spatial priority data products are summarized in Figure 2.

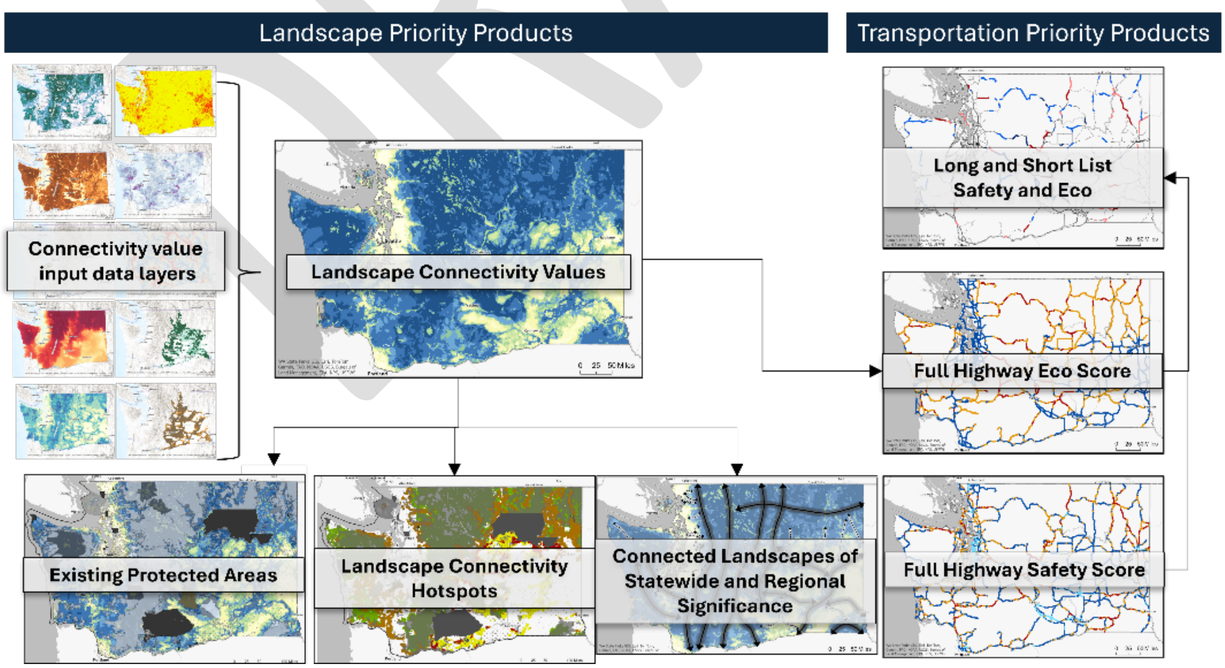

Figure 2. This diagram summarizes the key analytical products developed through the WAHCAP process. On the left, ten spatial input data layers were combined to produce the Landscape Connectivity Values map. The Landscape Connectivity Values map highlighted the significance of existing protected areas as connectivity anchors and informed the identification of the Full Highway System Rankings Ecological Value Score, Landscape Connectivity Hot Spots, and the Connected Landscapes of Statewide and Regional Significance. On the right, transportation analysis products include Ecological Value and Wildlife-related Safety scores for all highway segments and the resulting Priority Zones in the combined Long and Shorts Lists. Together, these products guide decisions about where connectivity conservation and mitigation efforts can have the greatest impact for habitat connectivity and wildlife-vehicle safety.

From Statewide Vision to Regional Action**:** While the statewide CLOSS network provides a critical big-picture road map, effective connectivity conservation also demands finer-grained, regional analyses. Each region of Washington has unique geography, ecosystems, land use patterns, and species needs that a statewide model can only approximate. Recognizing this, the WAHCAP report includes Regional Connectivity Profiles that refine statewide priorities by providing additional information about specific landscape conditions, threats, and opportunities within each region of the state. The regional profiles highlight areas where local connectivity conservation actions can strengthen the statewide system by enhancing permeability across fragmented areas, mitigating barriers, or restoring and reinforcing linkages.

Integrating Local Habitats and Knowledge**:** By design, the statewide connectivity modeling did not capture every area of local ecological importance. The CLOSS map highlights the most significant linkages for statewide landscape-scale connectivity, but many smaller habitat areas (e.g., urban riparian areas, parks, or isolated forest patches) do not appear as statewide priorities even though they are critical locally. Due to time and data constraints, WAHCAP was unable to incorporate a complete set of fine-scale local data in this statewide analysis. Local conservation practitioners and land managers are therefore encouraged to delineate specific landscape priority locations for connectivity at the local level. Regional and community-level data (e.g., county open space plans, land trust conservation maps, Tribal knowledge and priorities) can identify additional connectivity areas that are not adequately represented in the statewide analysis. An important next step for connectivity planning in Washington is to connect these local habitat connectivity priorities to the larger Connected Landscapes of Statewide Significance.

Implementation Pathways: Successful implementation of WAHCAP depends on systematically integrating habitat connectivity into existing planning, funding, and management frameworks across Washington. WAHCAP provides spatial products, strategies, and guidance to support implementation through several key pathways. First, the incorporation of connectivity into land-use planning under the Growth Management Act—through comprehensive planning, zoning codes, and critical areas ordinances—is crucial to protecting and restoring corridors across local jurisdictions. Second, voluntary conservation incentives offer essential tools to support private landowners in sustaining and restoring connectivity on working lands. Third, continuing and expanding partnerships with WSDOT to integrate habitat connectivity into transportation planning and infrastructure to reduce wildlife-vehicle collisions and restore landscape permeability. Finally, strategic management of public lands—including recreation planning, forest road decommissioning, and land management plan updates—will protect, enhance, and restore connectivity across Washington's extensive public land base. Across all implementation pathways, cross-jurisdictional collaboration, leveraging voluntary and regulatory tools, and using WAHCAP data as a foundation is essential to advancing a resilient, connected landscape for Washington's wildlife and communities.

Critical Roles of Riparian Corridors**:** Across all spatial scales—statewide, regional, and local—riparian corridors emerge as crucial conservation features, particularly in fragmented or human-dominated landscapes. Stream and river corridors often retain continuous strips of vegetation and undeveloped floodplain, making them natural pathways for wildlife movement through otherwise fragmented habitat. In urban or agricultural areas, for example, a riparian corridor may be one of the few intact habitat strips remaining. Riparian corridors also function as climate corridors, allowing species to shift along elevational gradients in response to warming temperatures. Protecting and restoring riparian areas supports both aquatic ecosystems and terrestrial wildlife movement. Examples like Crab Creek on the Columbia Plateau and the Chehalis River in western Washington illustrate how riparian networks can help reconnect fragmented habitats. Prioritizing riparian corridors in planning and restoration efforts is essential to sustaining connectivity at all scales.

Towards an Integrated Connectivity Network: WAHCAP presents a vision of landscape connectivity for Washington state. The identification of the 12 Connected Landscapes of Statewide Significance provides the framework, while regional profiles refine and fill in the network. This multi-scale approach is intended to empower conservation partners, land managers, and planners to align their work towards a common goal: **a Washington where wildlife and ecological processes can move freely across connected habitats, and where a safer statewide highway system reduces risks to both wildlife and people.** By connecting local landscapes to statewide corridors, prioritizing critical linkages like riparian corridors, and restoring areas where connectivity is most at risk, we can build a more resilient, adaptive, and safe Washington.

Introduction

Habitat connectivity describes how landscapes facilitate or impede animal movement and ecological processes. Wildlife depends on connected habitats to access food, water, shelter, migrate seasonally, establish new territories, and spread genes. Habitat connectivity also supports ecological processes such as seed dispersal and supports persistence of species important to cultural practices such as hunting and gathering.

Connectivity is essential in a changing climate, as connected landscapes allow wildlife to adapt and shift toward suitable habitats amidst changing environmental conditions. However, habitat connectivity in Washington is threatened by rapid population growth, increasing demand for housing, transportation, renewable energy infrastructure, and development. Balancing human needs with ecological functions is crucial. Sustainably managed working landscapes, like well-managed forestry and agriculture, are generally beneficial rather than detrimental to habitat connectivity.

This report outlines the purpose, guiding principles, goals, analyses, and implementation strategies and actions of the Action Plan. It also provides publicly accessible spatial data and technical appendices describing modeling methodology.

Purpose and Vision

> *The Washington Habitat Connectivity Action Plan is a science-based roadmap developed through a* ***collaborative partnership*** *to prioritize* ***places and projects*** *to* ***protect and enhance*** *habitat connectivity statewide.*

The WAHCAP vision supports informed understanding and effective planning for habitat connectivity in Washington State. The WAHCAP identifies critical locations that contribute to habitat connectivity at multiple spatial scales and highlights connectivity strategies to protect and enhance connectivity functions and values. The WAHCAP identifies existing strategies that can support connectivity conservation including transportation barrier mitigation, voluntary incentive programs, voluntary land acquisition, public land management, and land-use planning policies that facilitate wildlife movement. For any given location, a different combination of conservation strategies will be most effective to protect and restore habitat connectivity.

Guiding Principles

These guiding principles define the approach taken by the WAHCAP authors and underpin its methods, analyses, and priorities:

Integrate landscape and transportation connectivity. The WAHCAP addresses both landscape and transportation connectivity. The transportation analysis focuses on the

Washington Department of Transportation (WSDOT) administered highway system and addresses both wildlife movement and public safety. The landscape connectivity analysis evaluates connectivity functions and values for all of Washington state.

Focus explicitly on terrestrial wildlife connectivity. The WAHCAP focuses on terrestrial habitat connectivity. Aquatic connectivity and fish passage barriers, though ecologically crucial, are addressed by other groups and plans within the state including WDFW's Fish Passage Inventory, Assessment, and Prioritization program. Nonetheless, collaboration between aquatic and terrestrial connectivity efforts is strongly supported and encouraged. Projects to replace and improve fish passage barriers can often include design elements to help support and enhance terrestrial connectivity at comparatively little extra cost to the total project as long as terrestrial needs are included early in the design process.

Provide connectivity information at multiple scales. Resilient ecosystems require connectivity at multiple scales. While primarily identifying statewide and regional priorities, the WAHCAP provides spatial data from coarse (1-mile resolution) to finer-scale (polygon and 100-meter resolution), to help inform local prioritization and project planning.

Leverage existing data and fill critical gaps. The WAHCAP builds on Washington's longstanding leadership in connectivity mapping, relying heavily on existing connectivity data and analyses. In early discussions, stakeholders expressed concerns about outdated data and identified updating key existing datasets and developing new models as a needed action to fill identified data gaps. WAHCAP data reviewed and vetted existing data and strategically created new data to reflect current landcover and take advantage of new modeling technologies.

Amplify existing connectivity conservation efforts. The WAHCAP was developed to integrate and amplify existing connectivity priorities statewide, combining past and ongoing connectivity efforts with new data. This approach reveals consistently critical connectivity areas, leverages different scientifically valid approaches to prioritization, and provides a baseline to detect shifts in landscape priorities over time.

Prioritize immediate action over perpetual analysis. The WAHCAP is designed to be a living document. Connectivity mapping and science constantly evolves, and analyses can always be improved. The WAHCAP confidently identifies actionable, "no-regrets" locations for implementing connectivity conservation**,** based on more than two decades of connectivity research and expertise in Washington. The WAHCAP will be updated with new information as it becomes available. There are many recommendations within the WAHCAP that can be taken immediately to protect and restore connectivity in Washington, from the local to statewide scales. The Plan also identifies next steps for expanded analyses to provide more detail, include missing ecological elements, and better inform a wider range of users.

Goals

The WAHCAP framework centers four foundational goals—**Identify**, **Prioritize**, **Adapt**, and **Mainstream**—to guide connectivity conservation across Washington State (Figure 3). These goals outline an iterative approach, moving from identifying best available science to actionable, place-based priorities alongside strategies that embed connectivity into existing conservation and planning frameworks. Together, they form an interconnected cycle to ensure long-term ecological resilience.

*Figure 3. The four interconnected goals of the WAHCAP—**Identify**, **Prioritize**, **Adapt**, and **Mainstream**—illustrate an iterative approach to habitat connectivity conservation. These components collectively guide data-informed decisions, targeted connectivity conservation actions, adaptive responses, and integration into broader management practices.*

1. **Identify spatial data to guide connectivity conservation:** The WAHCAP provides spatial data at multiple scales to support informed connectivity conservation decisions, address key data gaps, minimize negative impacts to biodiversity, and guide proactive conservation efforts.
2. **Prioritize landscapes essential for connectivity:** The WAHCAP identifies statewide and regional connectivity priority locations based on ecological functions, values, threats, and implementation opportunities.
3. **Adapt and integrate emerging science into connectivity planning:** The WAHCAP develops an adaptive process that continually incorporates new science, data, and lessons learned from conservation actions into connectivity planning.
4. **Mainstream connectivity conservation into existing plans, policies, and procedures:** Implementation of the WAHCAP will depend on leveraging existing programs and resources to embed coordinated connectivity conservation within broader planning and management processes.

Roles of Teams and Advisory Groups

Development of the WAHCAP was led by the Washington Department of Fish and Wildlife (WDFW) in close collaboration with the Washington State Department of Transportation. The WAHCAP was a collaborative project co-produced by members of the conservation community throughout the state and across borders. The roles of the teams that developed the WAHCAP are described in Figure 4. In addition to these groups, any interested party could sign up for the WAHCAP mailing list to receive project updates and webinar invitations. Tribal members participated in the two advisory groups described here, and additional tribal engagement is described in more detail in the following section.

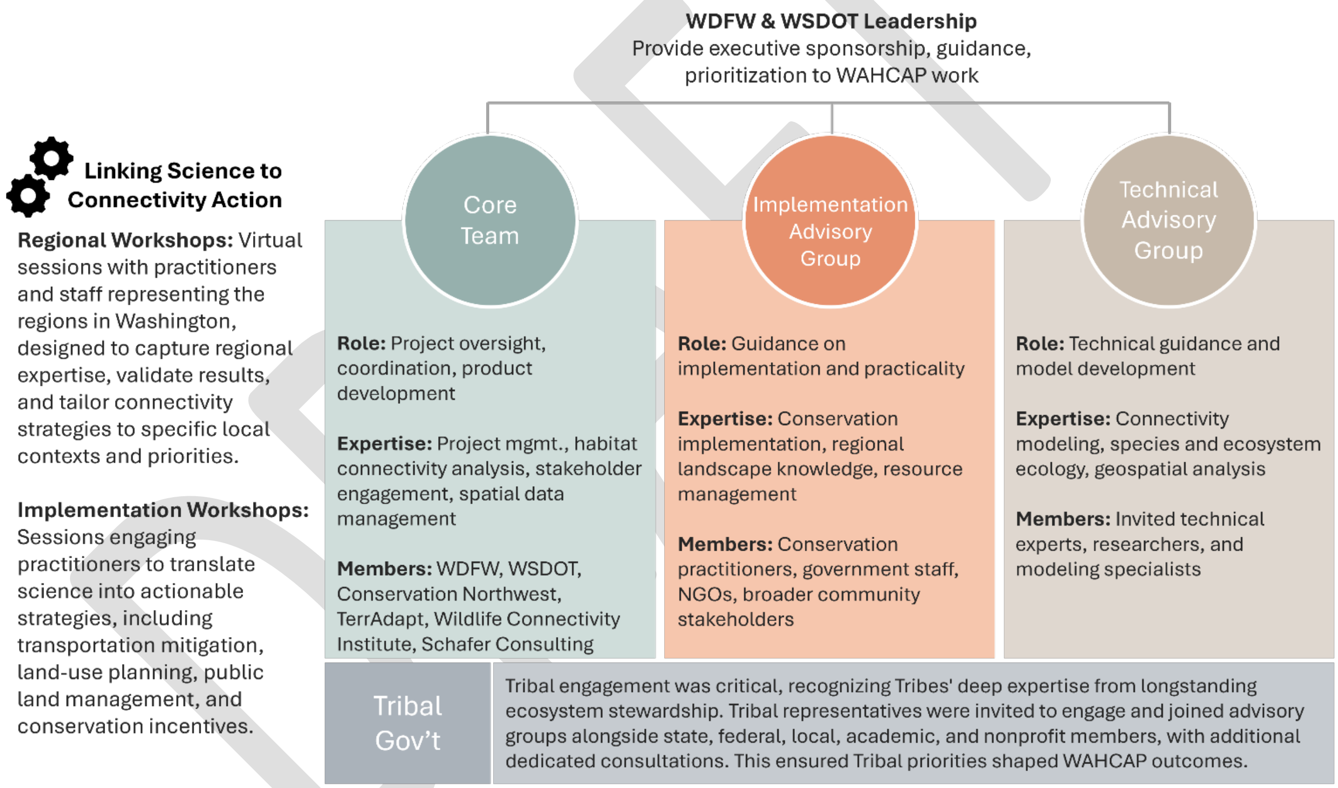

Figure 4. Organizational structure and science-to-action mechanisms for the WAHCAP.

Core Team. The Core Team met bi-weekly throughout the WAHCAP development to direct the project, organize and conduct advisory group meetings and other outreach, collect and respond to feedback, perform the prioritization analyses, write the report, and curate spatial data for public use. In addition to WDFW and WSDOT, the Core Team also included Conservation Northwest, TerrAdapt, the Conservation Biology Institute, the Wildlife

Connectivity Institute, and Schafer Consulting. The Core Team kicked off the project in January 2024 and completed it in June 2025.

Technical Advisory Group. The Technical Advisory Group (TAG) included invited individuals with technical expertise in connectivity modeling, species and/or ecosystem expertise, or similarly relevant knowledge. This group assisted in the review of existing data and models, development of the new connectivity models, and in the determination of how to combine and weight data. The TAG met approximately every other week between February and December of 2024.

Implementation Advisory Group. The Implementation Advisory Group (IAG) consisted generally of conservation practitioners, the targeted audience of the WAHCAP. Members included but were not limited to representatives of Tribal, federal, state, and local government; conservation organizations; universities; and consultants. The purpose of the IAG was to work with the Core Team to ensure that the final WAHCAP products met the needs of the conservation community and would lead to successful connectivity conservation projects on the ground. The IAG provided information about existing connectivity conservation successes and challenges, limitations of previously available data and resources, regional landscape expertise, and implementation opportunities, strategies, and resources. Membership in this group was largely open to any interested party. The IAG met in March, June, August, and November 2024. As the WAHCAP developed, invitations to workshops in January, March, and April 2025 were extended to all parties subscribed to the WAHCAP mailing list to capture a wide range of perspectives and feedback.

Tribal Engagement

WDFW and WSDOT recognize that Washington's Tribes have extensive knowledge of habitat connectivity due to their longstanding stewardship of regional ecosystems. Incorporating Tribal priorities was therefore a central goal of the project. WDFW and WSDOT invited all 29 federally recognized Tribes in Washington to participate throughout WAHCAP's development, while respecting tribal sovereignty and capacity.

Initial Outreach (June – September 2023): WDFW began Tribal engagement with a webinar in June 2023, hosted by WDFW's Director of Tribal Affairs. All Tribes, plus regional Tribal commissions (NWIFC, PNPTC, CRITFC), were invited. The webinar introduced the future WAHCAP's goals and opportunities for involvement, followed by a September email sharing the webinar recording and engagement opportunities, including an invitation to participate in advisory groups.

Formal Invitations and Consultations (February 2024): In February 2024, formal invitation letters were sent to each Tribe's leadership, detailing ways Tribes could participate, including one-on-one consultations and joining advisory groups:

- Eight Tribes responded, providing feedback or data.
- Five Tribes participated in individual meetings to discuss specific connectivity priorities and concerns.
- Tribal representatives joined WAHCAP's Technical Advisory Group (TAG) and Implementation Advisory Group (IAG), which also included state, federal, local, academic, and nonprofit members. Five Tribes joined the TAG and two joined the IAG.

Integration of Tribal Feedback: Tribal input significantly shaped WAHCAP, influencing focal species selection and identifying critical transportation barriers affecting wildlife connectivity.

Ongoing Collaboration and Feedback (April – September 2024): In April 2024, WAHCAP staff participated in the Affiliated Tribes of Northwest Indians (ATNI) Tribal Leaders Climate Summit. They presented a poster on the WAHCAP and shared information and gathered further input. A Tribal webinar in September of 2024 was held to ask Tribal representatives to review preliminary connectivity maps and data. Core Team members illustrated how earlier Tribal feedback was integrated. Tribal participants provided additional corrections and insights, further refining the connectivity models.

Final Workshops and Input (February – April 2025): In February and April 2025, Tribal-focused workshops allowed Tribes to review near-final priorities and strategies. The Core Team offered opportunities to adjust recommendations and suggest implementation partnerships. Tribes provided detailed feedback on alignment with their priorities and offered additional input on species and areas of concern, and future actions to protect and restore connectivity.

A final comment period in March–April 2025 allowed Tribes one more chance to submit written comments or meet directly with WAHCAP staff. Four Tribes provided substantive additional feedback, reinforcing their connectivity priorities. This final Tribal input was used to review and refine WAHCAP's spatial prioritization and recommendations.

Adaptive Planning Cycle

The WAHCAP is envisioned as a living document that will be updated as improved data becomes available or additional connectivity resources and plans are identified. It is not anticipated that significant changes in the overall prioritization will occur during these routine updates. However, the WAHCAP team is aware of plans to update and improve Species of Greatest Conservation Need data and individual focal species models. In addition, we recognize that the current version supplies insufficient information to understand and identify local connectivity priorities and support local planning. As additional data becomes available, it can be added to the WAHCAP spatial data collection, and we will seek to understand whether and how new data may impact or change existing priorities. A comprehensive review and update is intended approximately every five years, dependent on the availability of funding.

Data Availability

Spatial data from the WAHCAP analyses are available on ArcGIS Online including:

- Landscape and transportation priority locations.
- Landscape connectivity value input data at a finer resolution than the WAHCAP analysis.
- Key additional administrative layers like protected areas and roads.

The data can be viewed in a webmap or opened in desktop ArcGIS applications. Data will be available for download once the final WAHCAP is published. Additional instructions for accessing the data are available on the linked AGOL landing page.

Landscape Connectivity Science and Values

Elements of a Connected Network

Habitat connectivity is the ability of the landscape to facilitate or impede wildlife movement (Taylor et al. 1993).

A common understanding of connectivity form and function is important to identify appropriate and effective connectivity conservation actions. The word wildlife "corridor" often evokes a long, narrow strip of habitat or a pathway between two areas of habitat. However, in practice, connectivity takes many forms depending on the landscape condition, scale of analysis, and the species of wildlife under consideration. For example, a small parcel of high-quality land might form a crucial linkage between two important habitat areas; purchasing that parcel would effectively protect this "habitat corridor." By contrast, a large landscape mosaic of protected and sustainably harvested forests may provide "diffuse" connectivity without discrete corridors. Managing for this shifting mosaic of forested lands would be more feasible and better protect connectivity of that area than identifying and protecting a strict linear corridor.

Landscape connectivity can be considered and defined based on landscape and habitat structure or can be functionally determined for a focal species or group of species.

Important features of a connected landscape include habitat cores, corridors (or linkages), and areas exhibiting diffuse, concentrated, or channelized connectivity. These terms describe conceptual types of connectivity, each mapped using specific modeling frameworks. In the development of the WAHCAP maps, we sought to represent habitat connectivity realistically, without artificially narrow corridors unless supported by clear physical or structural landscape characteristics that would restrict movement to those narrower bands.

We briefly define and describe the different types of habitat connectivity here.

Cores

Conceptually, core areas are the places that a connectivity network seeks to connect. Cores are blocks of habitat large enough to support at least several home ranges for multiple individuals or species. These areas must have sufficient habitat quality and be of a sufficiently large size to support wildlife populations and their essential life history functions.

In connectivity modeling, cores are defined as relatively large, intact, high-quality blocks of habitat or target vegetation (Forman 1995). Areas within cores have a low human footprint and are internally well connected. Core areas themselves provide connectivity because they are internally cohesive and uninterrupted. Protecting intact core areas is thus essential to connectivity conservation (Fahrig 2003).

- Cores can be identified based on species-specific habitat requirements, ecosystems or habitat types in general, or simply natural vegetation.
- Definitions of cores as “large” or “high quality” are context-dependent, varying by species or habitat type, and by the spatial scale (statewide, regional, local) of the analysis or planning area.
- Protected areas or other “biodiversity areas” (i.e., locations with good habitat that support multiple or particularly rare species or habitats) can also serve as cores in a habitat connectivity network.

Corridors

Corridors are the pathways or linkages between habitat cores. For most large and highly mobile species, corridors provide habitat sufficient to facilitate movement but are not identified to sustain permanent populations. Species with limited mobility may need to reside within corridors and only achieve migration over multiple generations. In core-corridor modeling, corridors differ from cores because their habitat quality is lower or too linear to function as core habitat (Bennett et al. 2003, Hilty et al. 2012).

Diffuse, intensified, channelized, and impeded connectivity

These terms describe the characteristics of the habitat connectivity in the landscape. While used as general descriptors in this report, modeling frameworks can quantitatively classify the landscape into these categories (Schloss et al. 2021):

Diffuse connectivity: Widespread connectivity with few barriers to impede or constrain movement. No single identified pathway exists through these landscapes and thus wildlife can move freely without specific routes in the landscape.

Intensified (or concentrated) connectivity: Moderate habitat loss constrains or narrows movement options, forming wide but constrained corridors.

Channelized connectivity: High habitat conversion and modification results in a single remaining route through a heavily modified landscape.

Impeded connectivity: Wildlife movement is completely blocked or precluded, such as by high-traffic roads or a clearcut for species that require forest canopy.

Structural vs. functional habitat connectivity

The WAHCAP analysis primarily relies on *structural* connectivity— physical links between habitat areas with quality and connectivity value defined by the level of human landscape modification. Functional connectivity refers to how effectively wildlife could move or survive in these landscapes depending on habitat preferences and movement capabilities. Although the WAHCAP analysis relies heavily on structural connectivity, it also incorporates focal species connectivity models which aim to better represent functional connectivity and, when available, empirical movement data based on GPS collar tracking.

Structural connectivity was a focus for the WAHCAP analyses for several reasons:

- Empirical GPS collar data were available for a small number of species and for those species, within a subset of their full range. As a result, empirical movement data was extremely limited.
- In the absence of empirical movement data, the WAHCAP model prioritized connectivity for wildlife species sensitive to human modification of the landscape, as minimally disturbed areas are increasingly rare and essential for vulnerable species.
- Habitat with structural connectivity is likely to meet the functional needs for many species that use that vegetation type.

- The WAHCAP's broad-scale analyses are designed to inform landscape-level decisions. Detailed, fine-scaled evaluations can help identify which species are present and what habitat features would best support their connectivity needs for a given project site.

Protection, Enhancement, and Restoration

The WAHCAP analyses evaluated current landscape connectivity with a goal to identify locations that have some degree of existing connectivity functions and values to protect or enhance. The transportation analysis identified critical locations where WSDOT highways create barriers to wildlife movement, highlighting opportunities where mitigation of those barriers would substantially improve ecological connectivity and public safety by reducing wildlife-vehicle collisions.

Outside of this, the current WAHCAP analyses did not specifically model restoration priorities. Such a targeted restoration analysis, using finer-scale spatial techniques within identified regional fracture zones, would be a valuable future extension of this work. WAHCAP products can help inform siting and prioritization of restoration efforts that aim to expand or enhance existing connectivity. In addition, because the WAHCAP analyses were done at a statewide and regional scale, site-scale restoration needs will exist within locations identified as having broad-scale high connectivity functions and values.

Scale

Identifying priority locations is inherently relative—what is considered "best" or "most important" depends on the geographic extent of the analysis. Consequently, locations that are identified as priorities at the statewide level will differ substantially from those prioritized at region, county, or city scales.

The primary goal of the WAHCAP analyses was to identify connectivity priorities at the statewide scale. However, we strongly recognize and support the need for connectivity conservation at multiple scales. Given the time and data constraints of this project, WAHCAP prioritized locations at the statewide and regional (multi-county) scales.

New ecosystem connectivity data were created at three spatial scales: statewide, regional, and quasi-local (i.e., the data produced is *informative* to planning at the local scale even though it does not *comprehensively* identify local connectivity). Due to time and data limitations, detailed and comprehensive local-scale analyses were not possible but are an important next step for connectivity planning in Washington.

Landscape Connectivity Modeling Approach

There are a wide variety of scientifically valid methods for modeling wildlife habitat connectivity. The mapping used and created for the WAHCAP relied heavily on methods and approaches developed by the Washington Habitat Connectivity Working Group (WHCWG). The WHCWG's approach identifies "core" habitat areas first, then maps the optimal pathway among all adjacent core areas in the network. An alternative approach ranks landscape "permeability," assessing the degree to which human modifications impede wildlife movement without defining core areas to move between. Both approaches are valid and provide different, complementary information about the connectivity values present in any given location. The WAHCAP primarily relies on the core-corridor (or linkage) approach to modeling connectivity but includes a permeability data layer. For a more detailed review of these methods and their strengths and limitations, see Gallo et al. (2019).

Landscape Connectivity Values and Metrics

Through discussions with the TAG and IAG, we identified the following key elements to represent in our analysis of ecological connectivity functions and values.

- Ecosystem connectivity to provide a coarse-filter, structural baseline for habitat connectivity in Washington.
- Focal species to represent functional connectivity for species with a range of habitat preferences and movement capabilities.
- Biodiversity areas and locations supporting species of greatest conservation need.
- Protected areas designated and managed to support ecological functions – both to identify ecological strongholds for biodiversity conservation and to ensure connectivity among existing protected areas which is required to sustain their resilience.
- Existing connectivity priorities identified through scientifically valid and stakeholder-informed processes.
- Facilitating climate-change adaptation by ensuring a permeable landscape to allow for climate-induced range shifts and landscape movement to escape disasters (e.g., wildlife fire or flooding) and recolonize key habitats as they recover.

Based on these identified elements, the core team, in collaboration with the TAG, developed ten distinct metrics which were integrated to create a comprehensive surface of landscape structural connectivity value across Washington State (Table 1).

We developed new structural ecosystem connectivity data, which formed the foundation for mapping statewide connectivity values. These models were created based on current landscape conditions and mapped using a systematic method for the entire state – providing a consistent and current representation of structural habitat connectivity.

Additional critical biodiversity elements including westside prairies, species of greatest conservation need, and modeled habitat for focal species were added to this ecosystem baseline to better represent multiple dimensions of biodiversity based on available data.

Additional layers measuring network importance at the statewide scale, local permeability, and climate connectivity were included to represent connectivity network functions.

Finally, three existing prioritizations for the Columbia Plateau ecoregion – all developed through scientifically-valid processes with extensive stakeholder involvement – were included as valid analyses of conservation priorities on the Columbia Plateau. Inclusion of these existing prioritizations allowed users to directly compare existing prioritizations with each other and with new data. These complement each other by mutually reinforcing some locations as priorities based on multiple analyses and by identifying locations missed by other analyses.

The following table summarizes each input data layer used in this connectivity analysis, providing a description, rationale for inclusion, and an overview of the scoring and weighting methodology applied. Comprehensive details on methodologies, data processing, and original data sources for each input are in Appendix C. Landscape connectivity values data layer descriptions and Appendix E. Landscape values technical methods.

Table 1. Summary of spatial data layers used in connectivity prioritization, including their descriptions, rationales for inclusion, and scoring approaches. Detailed methodologies and data sources are available in Appendix C. Landscape connectivity values data layer descriptions and Appendix E. Landscape values technical methods.

Name	Description	Rationale	Scoring
Ecosystem Connectivity	Coarse-filter structural core and corridor models for four ecosystems (temperate forests, montane mesic forests, montane xeric forests, shrubsteppe) were developed by TerrAdapt. These ecosystems were delineated by climate, human footprint, and vegetation. Habitat cores and corridors were identified in a tiered approach relaxing the habitat conditions and human footprint resistance thresholds for each tier. These Ecosystem Cores and Corridors were then synthesized into a single Ecosystem Connectivity input layer.	Represent broad-scale, structural habitat connectivity, capturing habitat suitable for multiple species and the general movement routes connecting them.	Combined tiers (Tier 1 core > Tier 1 corridor > Tier 2 core > Tier 2 corridor > Tier 3 core > Tier 3 corridor); adjusted via a 20-mile radius moving window analysis to highlight top-scoring local areas.
Westside Prairie	Mapped potential prairie habitats in South Puget Sound based on prairie soils, minimal human disturbance, and absence of trees.	Addressed significant gaps for specialized habitat missed by broader ecosystem models.	Proportion of potential prairie habitat (prairie soils, low disturbance, no trees) within each 1-mile grid cell; inclusion equivalent to an additional ecosystem.
Permeability	A landscape permeability model assessed connectivity continuously across the landscape without predefined cores or corridors, quantifying the degree to which any unit of the landscape is connected to adjacent areas.	Provided complementary connectivity information independent of core-corridor structure, provides more detail in urbanized areas where cores were not identified.	Continuous landscape permeability score without discrete cores/corridors.
Network Importance	The importance of landscape routes and cores based on connectivity to larger, high-quality habitat areas at the statewide network level.	Highlighted regions most critical for statewide ecological connectivity, emphasizing routes connecting major habitat cores.	Continuous scores based on core size, quality, and centrality in the network; higher scores indicate higher statewide importance.

Focal Species Models	Connectivity models for 21 focal species reviewed by species experts, represented individual species' habitat and movement preferences.	Added species-specific detail to broader habitat-based connectivity, capturing diverse movement and habitat requirements.	Weighted sum of species in each grid cell, weights based on expert confidence in data; adjusted via 20-mile radius moving window analysis for regional species variation.
American Beaver (BIP)	Beaver Intrinsic Potential model predicting areas suitable for beaver establishment based on hydrology, vegetation and development pressure (Dittbrenner et al., 2018).	Identified beaver habitat concentration areas, addressing species-specific stakeholder priorities and connectivity needs.	Concentration of high intrinsic potential habitat for beavers (presence indicates higher scores).
Species of Greatest Conservation Need (SGCN)	Observed species range maps for 82 SGCN species from the State Wildlife Action Plan (SWAP), weighted by conservation priority and rarity.	Highlighted conservation-sensitive habitats critical for less mobile, smaller species with connectivity needs not captured in broader models.	Score weighted by species' federal/state protection status; higher counts and rarity yield higher scores.
Climate Connectivity	Continent-wide climate connectivity model (Parks et al. 2020) identified pathways important for facilitating climate-driven species range shifts.	Ensured connectivity analyses explicitly captured climate migration corridors under future climate scenarios.	Higher scores assigned to pathways most suitable for facilitating range shifts under climate change while avoiding human modification.
Arid Lands Initiative (ALI) & Priority Habitats and Species (PHS) Biodiversity Areas & Corridors (BAC)	Existing core and linkage prioritizations within the Columbia Plateau, synthesized from ALI and BAC data.	Incorporated regionally established connectivity priorities for shrubsteppe habitats, avoiding redundancy and ensuring alignment with existing conservation efforts.	Scored as 5 (ALI and BAC overlap), 4 (BAC only), 3 (ALI only), 0 (neither).
Washington Shrubsteppe Restoration & Resilience Initiative (WSRRI)	Spatial prioritizations for xeric and mesic shrubsteppe habitats, reflecting existing shrubsteppe conservation priorities.	Ensured WAHCAP incorporated active conservation priorities within the Columbia Plateau that slightly differ from new shrubsteppe models.	Highest-quality cores = 2; Growth Opportunity Areas (restorable cores) = 1; Corridors = 0.5.

Synthesized Landscape Connectivity Values Map

We combined the 10 input data layers to create a Landscape Connectivity Values map to highlight locations with high connectivity value at the statewide scale based on the input data layers gathered and summarized above. The Landscape Connectivity Values map is a critical input data layer to the Transportation Analysis and forms the basis for identifying locations where mitigating road barriers with wildlife crossing structures would provide significant ecological benefits.

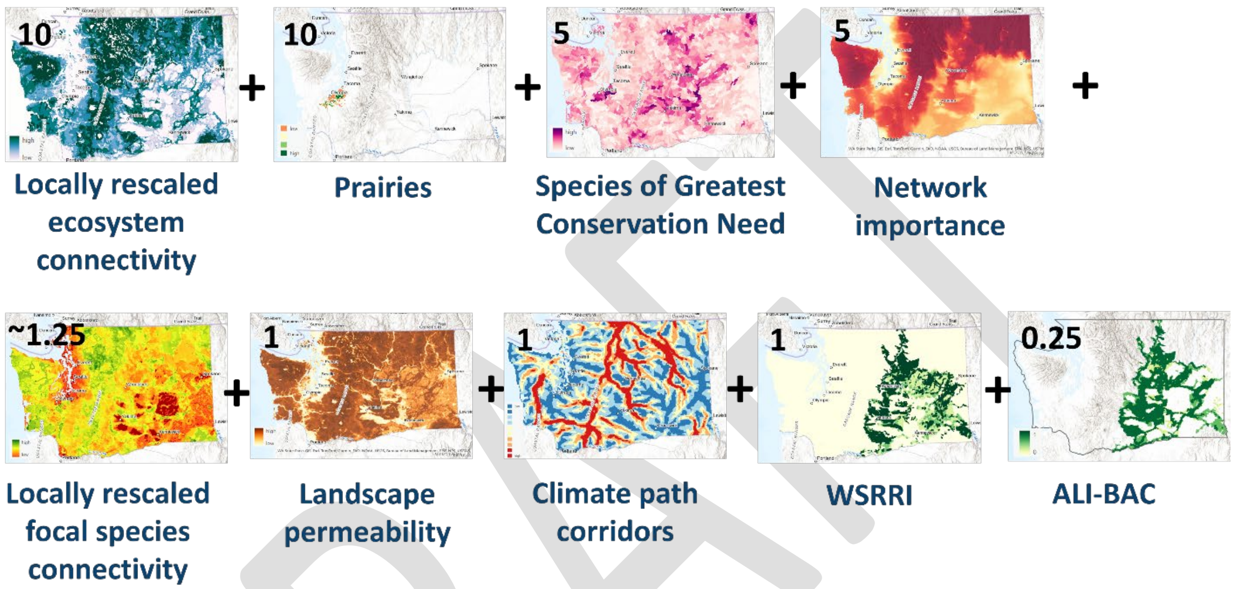

Figure 5. Illustrates of how each of the input connectivity value input data layers were added together to produce the final landscape connectivity value map. Each layer is described in Table 1. The numeric values in the upper left-hand corner of the layer image are the weights applied to that layer in the final summation. Weights were determined based on a combination of a) the importance of that data layer, b) our technical confidence in the validity of the data layer, c) the extent to which connectivity values in that data layer are also represented in other input data layers.

Each layer was weighted based on the importance of that connectivity element, confidence in validity of the data layer, and to balance any impacts to scores due to regional differences in data availability. We calculated the final Landscape Connectivity Values surface by summing the weighted contributions of all the individual metrics, weighted as shown in Figure 5. For clarity and ease of summarizing, we aggregated these metrics into a 1-mile square grid. Square grids offer a straightforward scaling into coarser-resolution grids (Birch et al., 2007). The resulting final landscape connectivity layer was a grid composed of 1-mile square units, with values ranging from 0 to 24 assigned to each cell. These values indicate landscape connectivity value based on the ten metrics employed, with higher values indicating more or greater connectivity values (Figure 6).

The overall distribution of scores skewed towards the high end of the total range. The mean score value for the state was 11 with a median value of 13. Although a higher cumulative score is one indicator of the presence of higher or multiple connectivity values, ***this score***

is a guide – not an absolute evaluation of connectivity value. Each individual connectivity data layer on its own represents an important aspect of connectivity and this statewide analysis is too coarse to adequately represent fine-scaled features that can be critical elements of connectivity at local scale. Table 2 offers guidance for how to interpret scores, while also emphasizing that these guidelines apply to decisions at the statewide scale. Decisions about the connectivity values within a region or for a specific location requires more detailed interpretation of underlying data. We recommend reaching out to WDFW for technical assistance for more detailed interpretation of connectivity value scores.

It is important to note:

- Scores are relative.
- The highest connectivity scores do not imply perfect ecological condition – but rather the highest values relative to other locations in the state.
- Low connectivity scores do not imply a lack of connectivity functions or value as this analysis does not capture fine-scale habitat features that contribute important functions at a local scale; many areas with low scores will have important localized or species-specific values.
- The synthesized landscape connectivity layer provides a holistic view; while the individual layers offer more insights for site-level planning and interpretation.

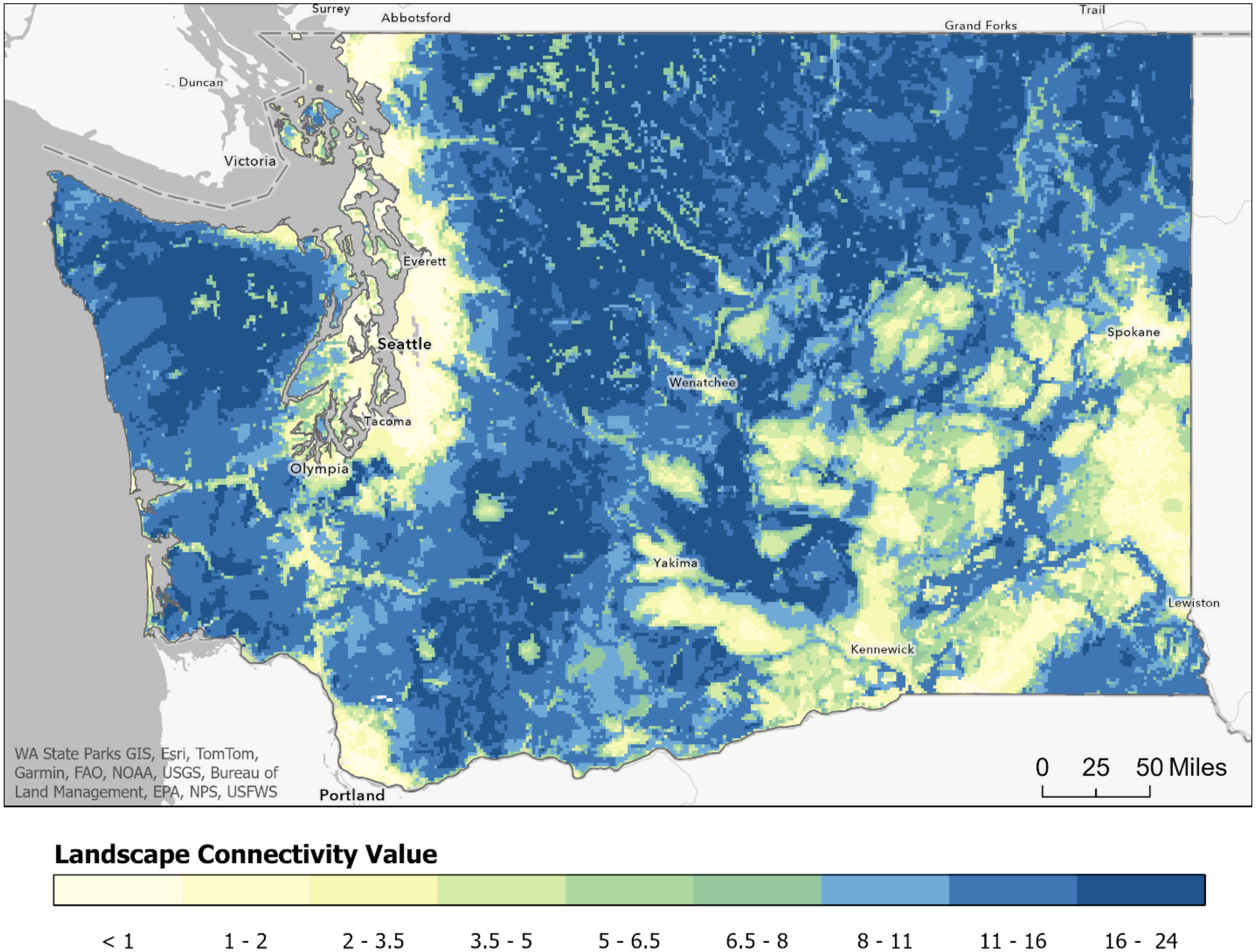

Figure 6. Statewide landscape connectivity value, calculated as a weighted sum of 10 input data layers described in Table 1.

Table 2. Interpretation of landscape connectivity scores at statewide and regional scales. This table provides guidance for interpreting the statewide landscape connectivity values used in the WAHCAP analysis. Each score range reflects a relative level of connectivity importance, both at the statewide scale and within more fragmented or regionally distinct landscapes.

Score	Connectivity category	General characteristics	Significance within the statewide context
>11	**Statewide:** Very high connectivity value	• Large, core areas of primarily native vegetation. • Lowest human footprint. • Multiple additional connectivity values (e.g., focal species, SGCN)	• Includes large, protected area cores, high value "buffer zones" surrounding protected area cores, and critical connections between large, protected areas. • Managing these landscapes to protect and maintain connectivity for wildlife is a very high priority at the statewide scale.
8-11	**Statewide:** High connectivity value **Regional:** Very high importance	• Intact vegetation. • Low human footprint. • Fewer additional connectivity values (e.g., focal species, SGCN).	• Locations scoring between 8 and 11 have high connectivity value at the statewide scale. • In landscapes with extensive development or fragmentation like the Columbia Plateau or the I-5 corridor, these scores highlight the most intact remaining habitat, forming critical links in the broader connectivity network.
5-8	**Statewide:** Moderate connectivity value **Regional:** High connectivity value	• Mixed landscapes of native vegetation and lower intensity human land uses. • Moderate human footprint. • Fewer additional connectivity values (e.g., focal species, SGCN).	• Mixed landscape connectivity regions support species that can move through agricultural, forestry, and mixed-use areas. • On the Columbia Plateau locations with scores between 5 and 8 identify areas that help widen or reinforce narrower high-value corridors or offer alternative routes across the landscape. In more channelized and fragmented areas, these scores typically represent the best remaining options for connecting more intact core areas.
1-5	**Statewide:** Low connectivity value **Regional:** Moderate to low connectivity value	• Intensive agricultural landscapes or lower density development. • Moderately high human footprint. • Fewer additional connectivity values (e.g., focal species, SGCN).	• More intensive agricultural or low-density developed areas can support movement for species (diffuse connectivity) that tolerate moderately high human landscape modification. • Fine-scaled habitat features—such as smaller patches of native vegetation, riparian corridors, or steep slopes—may offer high-quality local habitat and help maintain connectivity in the otherwise modified landscapes. These features are not well represented in statewide data.
< 1	**Statewide:** Not assessed **Local:** May contain fine-scale connectivity features	• Urban and suburban areas.	• This WAHCAP analysis was not designed to assess habitat connectivity in intensively developed landscapes (e.g., urban and urban fringe areas), so values in these regions are not well represented. As with more modified rural areas, fine-scale features (e.g., parks, riparian corridors) may still provide localized connectivity, but are better evaluated through local-scale planning.

Distribution of Landscape Connectivity Values in Washington State

Connectivity values are not evenly distributed across Washington, even after accounting for regional differences in data availability. The Ecosystem Cores and Corridors layer (Figure 7) provides the most consistent and fine-scaled assessment of structural connectivity due to uniform definitions of habitat quality and intactness and is referenced here as it establishes a consistent baseline for structural connectivity in the landscape connectivity values map. We recommend using the Landscape Connectivity Values map to provide a high-level overview of where multiple connectivity values coincide in the state and the Ecosystem Cores and Corridors layer to identify connectivity features at a higher resolution.

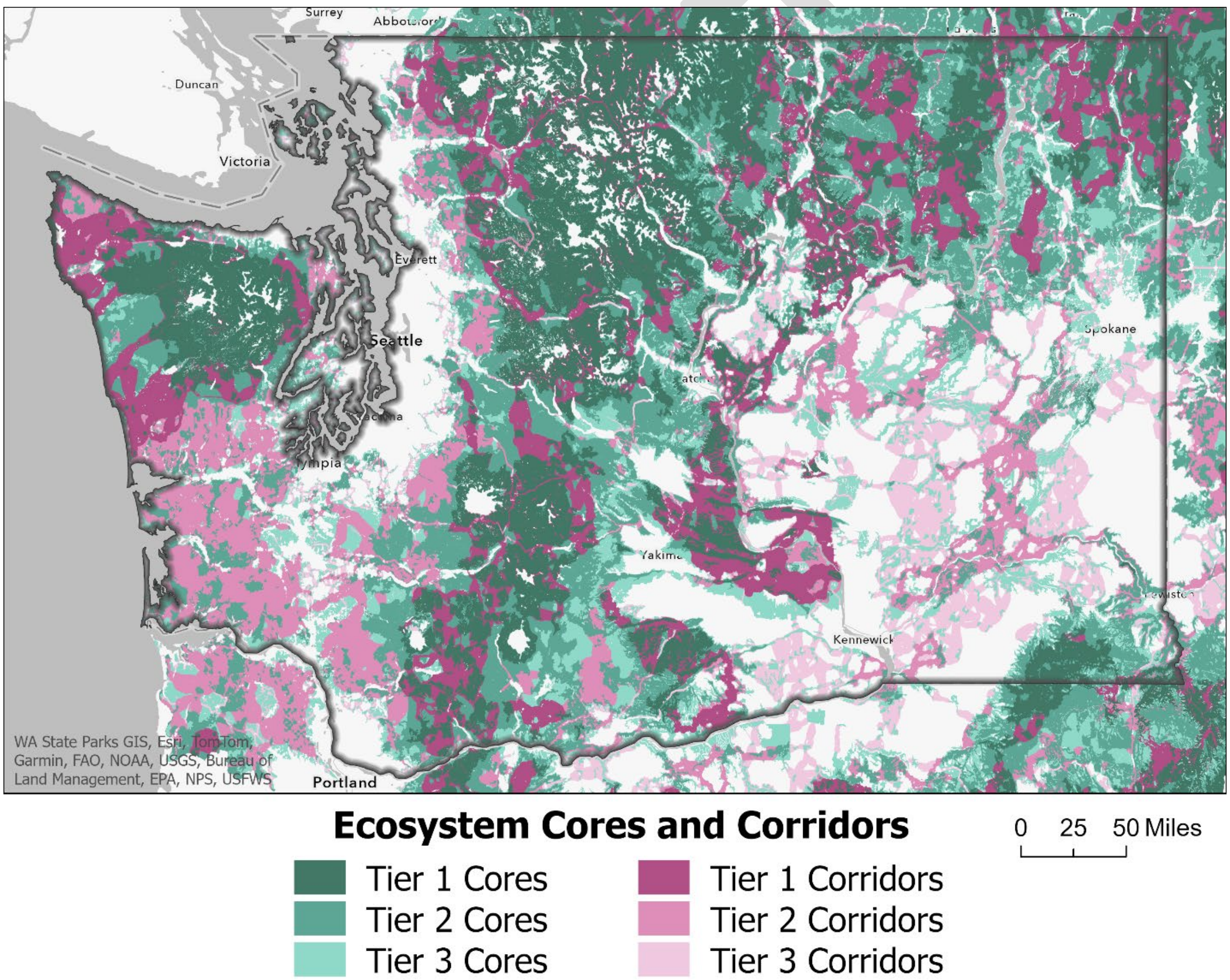

Figure 7. Tiered Ecosystem Cores and Corridors map. This map offers the most detailed, consistent, and current representation of structural ecosystem connectivity in the WAHCAP. We synthesized this map to create the Ecosystem Connectivity input data layer in the Connectivity Values Map. We recommend using this map to best identify structural connectivity features especially in highly fragmented or channelized landscapes.

High-value, diffusely connected landscapes

The Ecosystem Cores and Corridors analysis identified large, high-elevation public lands—such as Olympic, North Cascades, and Mt. Rainier National Pars; and the Olympic, Gifford Pinchot, Wenatchee, Colville, Kootenai, Coeur d'Alene, and Umatilla National Forests—as high-value core areas in the statewide network.

This designation does not imply these areas are ecologically undisturbed or without management challenges but instead reflects high native vegetation canopy cover and low human structural modifications relative to the rest of the state. It also represents their central location in the statewide network and the opportunity for landscape connectivity if managed for that purpose.

Mid-value, diffusely connected landscapes

In northeast and north central Washington, Tier 1 cores (Figure 7, see Table 1 for description of Tiers) are embedded in a diffusely connected landscape composed of mixed-age forest shaped by wildfire and logging. In lower elevation valleys in these regions, shrubsteppe and agriculture form ribbons of non-forested habitat. Roads and development are often concentrated in these valleys as well, creating narrow fracture zones or linear barriers limiting or reducing wildlife movement in otherwise diffusely connected landscapes.

Southwest Washington also features large swaths of diffusely connected mixed-age forest (Some Tier 1 and mostly Tier 2 ecosystem cores) in the Willapa Hills and lower elevations of southwest Washington and the Olympic Peninsula. In this region, connectivity is further limited by highways and associated residential and commercial development. I-5 is the most severe and complete barrier to wildlife movement between this region and the rest of the state.

Intensified and channelized landscapes

The Columbia Plateau exhibits a comparatively discrete network of some large habitat blocks and linear corridors set within a matrix of agricultural lands of varying intensity. The region's core and corridor habitat have been the focus of multiple past analyses—each developed to support similar but slightly different conservation objectives, such as shrubsteppe species recovery and wildfire resilience. The WAHCAP builds on and synthesizes these prior efforts, integrating them into a single framework for identifying and evaluating connectivity priorities at a statewide scale. This synthesis enables more consistent spatial interpretation and supports coordinated planning across jurisdictions.

Places with "low" connectivity values at the statewide scale

Several regions in Washington, including large portions of the Columbia Plateau and the Palouse, received comparatively low connectivity values in the synthesized statewide analysis. This result reflects the design of the analysis, which emphasizes connected networks of native vegetation as proxies for structural connectivity. The underlying assumption is that species vulnerable to habitat fragmentation are those that rely on native vegetation to disperse, migrate, or access resources. Consequently, areas dominated by intensive agricultural land use—where native vegetation is sparse or patchy—tend to score relatively lower at the statewide scale.

However, these lower scores should not be interpreted as evidence of ecological irrelevance. Many species, particularly generalists or those adapted to edge habitats, can move through agricultural landscapes. For such species, the Columbia Plateau remains permeable. Supporting this, the Washington Shrubsteppe Restoration and Resilience Initiative (WSRRI) identifies extensive swaths of agricultural lands as functioning corridors for sagebrush-associated species. Similarly, WAHCAP's permeability data—which accounts for structural landscape resistance rather than just native vegetation cover—assigns moderate permeability scores to many agricultural areas, indicating a degree of functional connectivity that is not captured by the native vegetation framework alone. These differing approaches do not represent better or worse methods for modeling connectivity but do highlight that what is "connected" is highly dependent on a species' tolerance of different habitat conditions.

The highly developed, low elevation regions of Puget Sound and western Washington are assigned the lowest scores for landscape connectivity values. These urban landscapes are characterized by dense human development but contain a highly heterogenous mix of landcover types including urban parks, riparian corridors, native vegetation remnants and gradients of suburban and rural housing densities. As in agricultural landscapes of the Columbia Plateau, many species utilize or move through exurban, suburban, and even urban landscapes. The Ecosystem Core and Corridors analysis includes identification of smaller habitat cores and corridors along the urban fringe, but the coarse spatial resolution of statewide data and satellite imagery mean that fine-scale features—such as ridgelines or narrow riparian corridors—are frequently underrepresented. This limitation underscores a key constraint of statewide-scale modeling: features that are critically important for local or species-specific movement may not be captured in a 30-meter pixel-based analysis. In both agricultural and urban landscape contexts, finer-resolution, locally tailored studies are needed to assess functional connectivity with greater ecological specificity.

Transportation Prioritization Methodology

Washington's highways simultaneously connect human communities and fragment wildlife habitats, creating barriers to wildlife movements and increasing the risk of wildlife-vehicle collisions. The WAHCAP transportation prioritization is a spatially explicit, scientifically rigorous prioritization of the state highway network that highlights segments where mitigation efforts would deliver the most significant ecological connectivity improvements and reductions in wildlife-vehicle collisions.

The prioritization process began by dividing the entire state highway network—approximately 7,000 linear miles—into standardized one-mile segments. Each state highway segment was then independently assessed for:

- **Ecological Value**: Importance to habitat connectivity.
- **Wildlife-Related Safety**: The potential for wildlife-vehicle collisions.

This dual scoring framework mirrors WSDOT's existing approaches and supports decision-making where both ecological importance and public safety are priorities.

Ecological Value

The Ecological Value score for each highway segment was primarily based on the synthesized Landscape Connectivity Values map developed for the landscape prioritization. Each one-mile segment was assigned a raw score equal to the average Landscape Connectivity Value score immediately adjacent to the road segment.

As traffic volumes increase, highway avoidance becomes the primary response of wildlife, when combined with road-associated mortality, this creates significant barriers to wildlife movement. Roads carrying 10,000 vehicles per day or greater are generally considered complete, or near-complete barriers to wildlife movement (Charry and Jones 2009). We use Annual Average Daily Traffic volume to represent the barrier effect of each highway segment to wildlife movement (Annual Average Daily Traffic [AADT]; Table 3). The combination of landscape connectivity value and traffic volume identifies locations where high ecological connectivity values are currently impeded by roads and traffic.

Table 3. Traffic volume categories (Annual Average Daily Traffic, AADT) and corresponding weights applied to raw Landscape Connectivity Value scores, reflecting the increasing severity of habitat fragmentation as highway traffic volumes rise.

Traffic Volume (AADT)	Ecological Value Score Weight
0 – 1,999 vehicles per day AND Raw Landscape Connectivity Value Score < the mean	1

0 – 1,999 vehicles per day AND Raw Landscape Connectivity Value Score >= the mean	1.25
2,000 – 9,999 vehicles per day	1.5
≥ 10,000 vehicles per day	2
≥ 33,000 vehicles per day AND Raw Landscape Connectivity Value Score >= the median	3

The Ecological Value scores of the full highway network were then analyzed using an Optimized Hot Spot Analysis to identify clusters of high-scoring segments. After filtering out clusters shorter than two miles and segments identified because of their proximity to adjacent high-scoring highways rather than their own value, this analysis produced 96 Ecological Value Priority Zones ranging in length from 2 to 42 miles and encompassing approximately 11% of the state highway system's linear miles.

Wildlife-Related Safety Value

The Wildlife-related Safety score for each highway segment was based on carcass removal data, wildlife-vehicle collision (WVC) reports, human injuries and fatalities, and intersection with the Ecosystem Cores and Corridors data layer (Figure 7) as an indicator of potential habitat as described in Table 4.

Table 4. Summary of metrics to calculate the Wildlife-related Safety score for the one-mile segments of the Full Highway System Rankings. Detailed methodologies and data sources are available in Appendix D. Transportation Connectivity Prioritization Technical Methods.

Name	Description	Rationale	Scoring	Weight	Source
Carcass Removal Records	Records of large animal carcasses removed from state highways (2019-2023). Black-tailed deer, white-tailed deer, mule deer, Columbian white-tailed deer, ek, moose, black bear, bighorn sheep, cougar, bobcat, wolf, wolverine.	Identifies road segments with the highest densities of carcass removals, presumably due to wildlife-vehicle collisions.	Sum of carcass removals by species.	If within species-specific carcass hot spot: • Deer = 2 • Elk = 5 • Large Carnivore (black bear, bobcat, cougar, wolf, wolverine) = 8 • Moose = 8 • Bighorn sheep = 8	WSDOT
Wildlife-Vehicle Collision (WVC) Records	Law enforcement records of wildlife-vehicle collisions with deer and elk (2019-2023), reported at the time of a collision. These are only required if a human injury occurs or estimated damages exceed $1,000 USD.	Identifies road segments with the highest densities of WVCs	Sum of WVCs by species.	Same as above for Carcass Removal Records	Washington State Patrol
Human Injuries	Human injuries and fatalities resulting from WVCs.	Focus on human health and safety.	Sum of human injuries or fatalities.	• 1 human injury = 2 • ≥2 human injuries = 8 • Human fatality = 16	Washington State Patrol
Ecosystem Cores and Corridors Map	Ecosystem Cores and Corridors, the precursor to the Ecosystem Connectivity input layer for the synthesized Landscape Connectivity Values map.	Identifies potential large animal habitat and ensures segments are not overlooked due to lack of recorded carcass removals or collisions.	Add 1 point if highway segment intersects layer	N/A	TerrAdapt

The Wildlife-related Safety scores of the full highway network were then analyzed using an Optimized Hot Spot Analysis to identify clusters of high-scoring segments. After filtering clusters shorter than two miles and segments identified because of their proximity to adjacent high-scoring highways rather than their own value, this analysis produced 60 Wildlife-Related Safety Priority Zones ranging in length from 2 to 20 miles and encompassing approximately 6% of the state highway system's linear miles. Detailed methodologies and data sources for the transportation analysis are available in Appendix D. Transportation Connectivity Prioritization Technical Methods.

Statewide Transportation and Landscape Connectivity Priorities

A primary goal of this Plan is to identify priority locations for connectivity conservation action at the statewide scale. Figure 8 and the following section walks through the transportation and landscape priorities identified by the WAHCAP analyses.

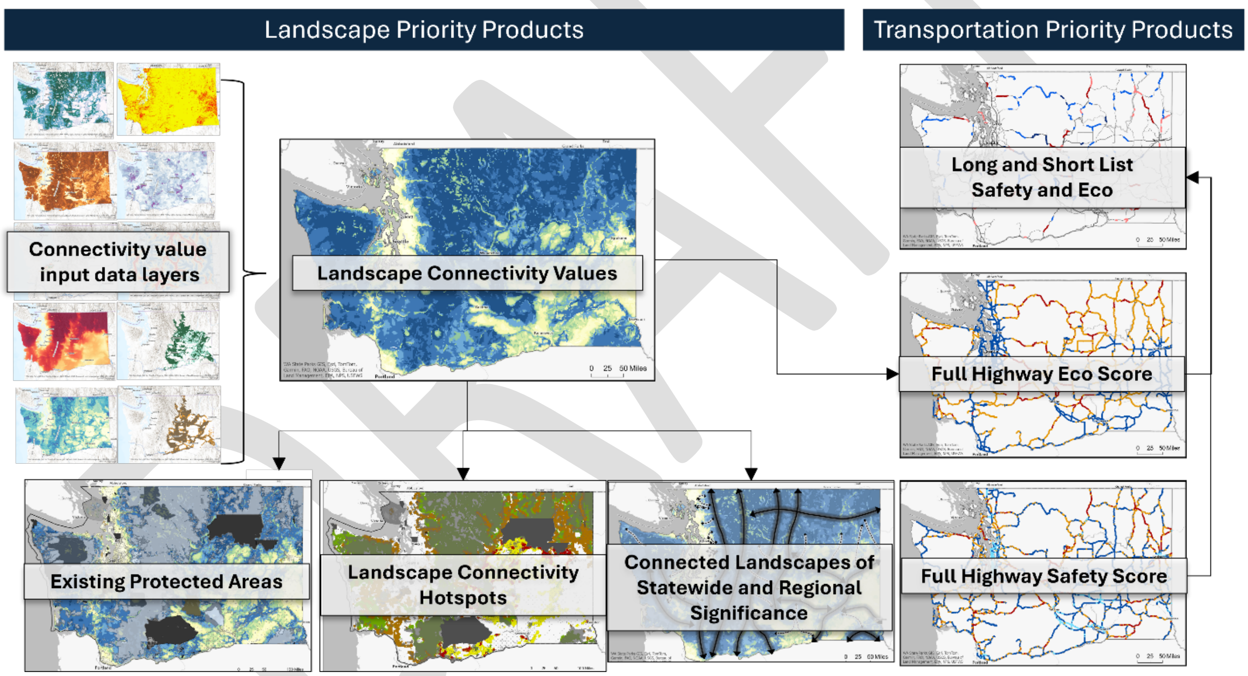

Figure 8. This diagram summarizes the key analytical products developed through the WAHCAP process. On the left, ten spatial input data layers were combined to produce the Landscape Connectivity Values map. The Landscape Connectivity Values map highlighted the significance of existing protected areas as connectivity anchors and informed the identification of the Full Highway System Rankings Ecological Value score, Landscape Connectivity Hot Spots, and the Connected Landscapes of Statewide and Regional Significance. On the right, transportation analysis products include Ecological Value and Wildlife-related Safety scores for all highway segments and the resulting Priority Zones in the combined Long and Shorts Lists. Together, these products guide decisions about where connectivity conservation and mitigation efforts can have the greatest impact for habitat connectivity and wildlife-vehicle safety.

Our analysis identified 38 discrete locations on state highways that offer the greatest potential for coordinated road barrier mitigation actions, including wildlife crossing structures, fencing, and other measures to facilitate safe passage for wildlife and reduce wildlife-vehicle collisions. We also identified over 100 additional priority areas with high ecological or safety value and developed Ecological Value and Wildlife-related Safety rankings for every one-mile segment of the state highway system. These rankings are organized in a nested framework, with the Full Highway System Rankings providing the most comprehensive view and progressively filtering into the Long List and Short List of Priority Zones (Full Highway System Rankings > Long List > Short List).

Identifying discrete landscape priority locations analogous to the transportation priorities proved challenging due to the gradient nature of ecological connectivity. Defining discrete landscape "units" imposes artificial boundaries on ecological and functional continuity. Instead, we present a framework for prioritizing locations for landscape connectivity conservation.

Statewide Transportation Connectivity Priorities

The transportation analysis resulted in three main products: 1) Full Highway System Rankings for Ecological Value and Wildlife-related Safety, 2) a Long List of transportation Priority Zones, and 3) a more selective Short List of transportation Priority Zones. For each of these products, we provide intended uses and results based on the Ecological Value and Wildlife-related Safety analyses.

Full Highway System Rankings: We independently calculated Ecological Value and Wildlife-related Safety scores for each one-mile segment of the full state highway system, using the methods discussed above and detailed in Appendix D. Transportation Connectivity Prioritization Technical Methods. These scores were used to assign each segment to a priority rank of high, medium, or low. An additional category, no rank, was included in the Wildlife-related Safety category only (Figure 9).

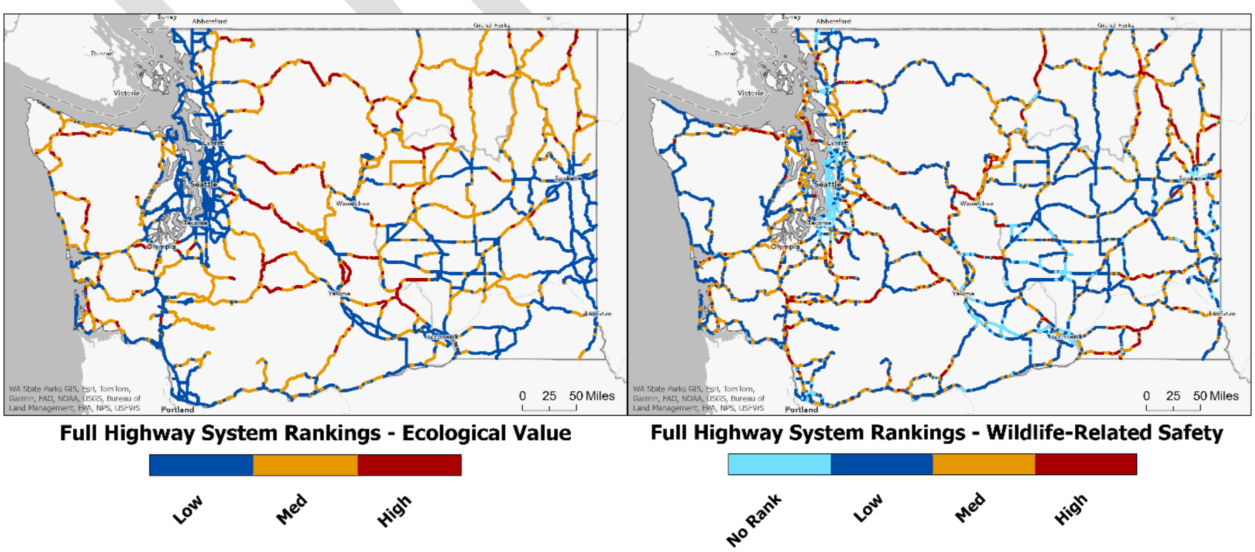

Figure 9. Ecological Value (left) and Wildlife-related Safety (right) scores for one-mile segments across Washington's full highway system. Ecological Value scores were calculated based on landscape connectivity value and traffic volume. The top 10% of segments are scored High, the next 40% are Medium, and the lower 50% are scored Low. Wildlife-related Safety scores were calculated based on wildlife carcass and collision data, human injuries and fatalities, and overlap with ecosystem cores and corridors. The top 10% of segments are scored High, the next 29% are Medium, the next 51% are Low, and the remaining 10% have No Rank.

Segments scoring in the 90th percentile for either category were identified as high priority. These rankings form the most comprehensive list in our prioritization framework and will serve as an update to WSDOT's "Habitat Connectivity Investment Priorities." Under WSDOT Executive Order 1031.02, *Protections and Connections for High Quality Natural Habitats*, WSDOT is directed to use the Habitat Connectivity Investment Priorities to identify opportunities for restoring connectivity across transportation corridors. The executive order calls for integrating these priorities into long-range planning, highway improvement projects, and highway maintenance. Mitigation actions such as wildlife crossing structures and barrier fencing are explicitly recognized as effective strategies.[1]

Critically, these rankings facilitate early identification of high priority areas, ensuring habitat connectivity considerations can be embedded in transportation planning from the outset—even when not a primary project goal initially (Environmental guidance for planning studies | WSDOT). Additionally, they provide a foundation for aligning fish passage barrier removal projects with terrestrial wildlife connectivity needs. WSDOT policy (Wildlife Habitat Connectivity Considerations in Fish Barrier Removal Projects) directs staff to evaluate fish barrier removal projects in areas identified as high priority for terrestrial wildlife habitat connectivity and to enhance those projects to improve connectivity for all species, where appropriate and cost-effective. The Full Highway System Rankings will be utilized to identify these high priority areas and resulting fish passage projects of interest.

After accounting for overlap between high-ranking segments in both categories approximately 19% of the state highway system's linear miles were classified as high priority. Score ranges were as follows:

- Wildlife-related Safety scores: 0 to 158 (mean = 7.63, median = 3.0)
- Ecological Value scores: 0 to 47.653 (mean = 10.12, median= 8.99).

[1] Make use of the highway prioritization map known as Habitat Connectivity Investment Priorities as a means to locate specific opportunities to restore habitat connectivity already damaged by human transportation corridors. The identified priority highway segments should be the focus of efforts to reduce wildlife-vehicle collisions and improve connectivity. Long-range planning, highway improvement projects, and highway maintenance all have a role in maintaining and improving connectivity in priority areas. Building and maintaining wildlife crossing structures and barrier fencing are effective actions. (WSDOT Executive Order 1031.02)

The top two scoring Wildlife-related Safety and Ecological Value *one-mile segments* are summarized below to demonstrate how priorities were set, how data can be interpreted, and illustrate the range of implementation strategies that may apply when utilizing the Full Highway System Rankings.

Wildlife-Related Safety Highlight 1: US 2, approximately two miles west of Cashmere, had the highest Wildlife-related Safety score (158) statewide.

Between 2019 and 2023, this one-mile segment recorded:

- **Deer-related incidents (102 points):** 32 deer carcass removals and 19 deer crash reports. As this segment falls within a deer carcass removal hot spot, the total (51) was weighted by a factor of 2 to reflect the significance of repeated incidents in this location, contributing 102 points.
- **Elk-related incidents (15 points):** Two elk carcass removals and one elk crash report. As this segment falls within an elk carcass removal hot spot, the total (3) was weighted by a factor of 5, contributing 15 points.
- **Human safety-related factors (40 points):** 5 human injuries resulting from wildlife-vehicle collisions, the most in a single one-mile segment. These were weighted by a factor of 8, contributing 40 points.
- **Habitat factor (1 point):** The highway segment intersected suitable large animal habitat and received one additional point.

These values totaled a Wildlife-Related Safety Score of 158 (102+15+40+1=158).

While this score reflects a high Wildlife-related Safety score, the segment's ecological context reinforces its importance for barrier mitigation. It spans a critical transition zone between high-use wintering ranges of two mule deer herds: the Chelan herd to the north in the foothills of east Cashmere and the Wenatchee Mountain herd in the foothills west and south of Wenatchee (Kauffman et al. 2022). Habitat directly adjacent to the highway—dominated by apple orchards—further contributes to collision risk. These orchards are highly attractive to deer and frequently coincide with areas of high deer-vehicle collision rates in eastern Washington.

Importantly, this one-mile segment includes a large-span bridge underpass on the Wenatchee River, offering a strategic and cost-effective opportunity for targeted retrofits. Installing wildlife barrier fencing, removing or restructuring riprap to provide wildlife benches that are easily traversable, and managing human access would significantly reduce wildlife-vehicle collisions and associated human injuries, while providing a pathway for migratory and resident wildlife to safely pass beneath the highway.

Wildlife-Related Safety Highlight 2: US 97, south of Tonasket, received the second highest Wildlife-related Safety score (155) statewide.

Between 2019 and 2023, the following incidents were recorded:

- **Deer-related incidents:** 69 deer carcass removals and 6 deer crash reports. As this segment falls within a deer carcass removal hot spot, the total (75) was weighted by a factor of 2, contributing 150 points.
- **Elk-related incidents:** 2 elk carcass removals occurred outside of an elk hot spot and were not weighted, contributing 2 points.
- **Human-safety related factors:** 1 human injury was recorded, weighted by a factor of 2, contributing 2 points.
- **Habitat factor:** 1 point added for intersecting suitable large animal habitat.

These values totaled a wildlife-related safety score of 155 (150+2+2+1=155).

US 97 bisects habitat inhabited by the Okanogan mule deer herd, one of the largest herds in the state. This segment is flanked by the Okanogan River to the west and apple orchards to the east—features that draw mule deer movement across the corridor and elevate collision risk.

This segment has a large-span bridge over the Okanogan River, Janis Bridge, 200 yards to the south. In 2019, Conservation Northwest (CNW), WSDOT, and partners installed approximately one mile of wildlife barrier fencing at the south end of Janis Bridge, resulting in up to a 90% reduction in collisions and thousands of mule deer crossings beneath the bridge annually, as well as 19 other species documented utilizing the bridge underpass. A similar retrofit to the north end of this bridge—ideally coordinated with nearby industries and planned mitigation—would likely result in comparable benefits.

Ecological Value Highlight 1: I-90, east of Snoqualmie Pass between Keechelus and Kachess Lakes, received the highest Ecological Value score statewide (47.654).

- **Raw Landscape Connectivity Value score:** 15.885 (statewide Landscape Connectivity Value score median = 5.98).
- **Traffic-volume weighting:** Based on average annual daily traffic volume of 34,000 vehicles, this one-mile segment falls into the highest AADT tier and received a weighted multiplier of 3
- **Total Score:** 47.654 (15.885*3=47.654).

This stretch of I-90 bisects Okanogan-Wenatchee National Forest, and because of its extreme traffic volume, is considered a complete barrier to wildlife movements. This segment falls within Phase 4 of the Snoqualmie Pass East Highway Widening Project, which will include four wildlife underpasses, from large-span bridges to smaller culverts, as well as wildlife exclusion fencing by 2028/2029. Wildlife connectivity was a central planning objective from the project's initial stages, reflecting a strong interagency partnership with the United States Forest Service.

Ecological Value Highlight 2: I-90, west of Snoqualmie Pass and immediately west of the Denny Creek exit, is the second highest-scoring segment for Ecological Value statewide (47.228).

- **Raw Landscape Connectivity Value score**: 15.743 (statewide raw Landscape Connectivity Value score median = 5.98).
- **Traffic-volume weighting:** Based on average annual daily traffic volume of 38,000 vehicles, this one-mile segment falls into the highest AADT tier and received a weighted multiplier of 3.
- **Total score:** 47.228 (15.743*3=47.228)

This stretch of I-90 bisects Mount Baker-Snoqualmie National Forest, and because of its traffic volume, is considered a complete barrier to most species' movements. A high diversity of species inhabits the area, including threatened and endangered ones, with wolverine (2018) and wolf (2015) carcass removals recorded within two and five miles, respectively. Long-term camera monitoring documented cougar kittens within 0.25 miles of this segment, as well as consistent and profuse elk activity directly adjacent to I-90. Currently, there are no existing or planned wildlife crossing structures. A standalone wildlife crossing structure project would likely be required to increase permeability.

Transportation Priority Zones – Long List: The Long List of transportation Priority Zones includes 156 Priority Zones—each representing a contiguous stretch of highway longer than one mile—identified by an optimized hot spot analysis to represent clusters of high Ecological Value or Wildlife-related Safety scores. The list comprises:

- 96 Ecological Value Priority Zones
- 60 Wildlife-related Safety Priority Zones

Together, these Priority Zones represent approximately 16% of the state highway network by linear mileage, accounting for overlap between categories. Because transportation priorities are structured in a nested hierarchy, all Short List Priority Zones (described below) are also part of the Long List. This design allows users to access both a broad statewide view and a refined subset of areas for focused attention.

To further inform mitigation strategies, the 96 Ecological Value Priority Zones should be considered in the context of traffic volume, which affects wildlife movement capability.

Road permeability classifications (Table 5) provide insight into how AADT influences connectivity for high- and low-mobility species.

In addition, species data compiled from WDFW's Priority Habitats and Species (PHS), Species of Greatest Conservation Need (SGCN), and Wildlife Occurrence data are available for each Ecological Value Priority Zone (see Appendix B. Transportation Connectivity Priority Zones). These data identify notable species observed within two miles of Ecological Value Priority Zone boundaries, helping planners assess site-specific species considerations and tailor mitigation strategies accordingly.

Table 5. Traffic volume categories and associated road permeability

Ecological Value Priority Zone AADT	Count of Long List Ecological Value Priority Zones	Terrestrial Wildlife Connectivity Road Permeability
<2,000	35	High permeability for high mobility species. Low to moderate permeability for low mobility species.
2,000-9,999	44	Moderate permeability for high mobility species. Low to no permeability for low mobility species.
10,000-32,999	11	Low to no permeability for most species.
>=33,000	6	No permeability. Roadway avoidance is the primary response of wildlife.

Transportation Priority Zones – Short List: The following criteria were used to narrow the Long List down to a more selective Short List of statewide priorities:

- **Top 25% scoring zones**: The top 25% of both Ecological Value and Wildlife-related Safety Priority Zones were included in the Short List.
- **Overlapping zones:** If an Ecological Value and Wildlife-related Safety Priority Zone overlapped and at least one of them scored in the top 25%, the full length of both Priority Zones was considered a single Short List Priority Zone.
    - This created discrepancies between the number of Priority Zones on the Long List, which are not combined, and the number of Priority Zones on the Short List, which are combined (the 38 Priority Zones of the Short List are analogous to 49 Priority Zones on the Long List) This is mostly for communication purposes, but Priority Zones are displayed independently in GIS data.

- **Elk-specific safety zones:** The top four elk-vehicle collision Priority Zones from the Long List were included, regardless of overall ranking. Two of these were already captured by the Top 25% scoring zones (first criteria).
- **Proximity-based merging:** If two Long List Priority Zones were separated by a mile or less *and* at least one met any of the above criteria, they were combined into a single Priority Zone on the Short List. This applied to two locations.

The Short List (Figure 10) comprised 6% of the state highway network's linear miles. It captures the top-scoring Priority Zones for each category, offering the most significant potential benefits from mitigation such as building wildlife crossings. These areas are ideal candidates for large-scale standalone connectivity projects, often funded through federal grants unless they coincide with other major transportation projects that can be enhanced for wildlife passage. They support strategic coordination of conservation efforts across agencies, jurisdictions, and partners – focusing efforts on highly-recognized, named locations crucial for achieving substantial ecological connectivity improvements and significant reductions in wildlife-vehicle collisions.

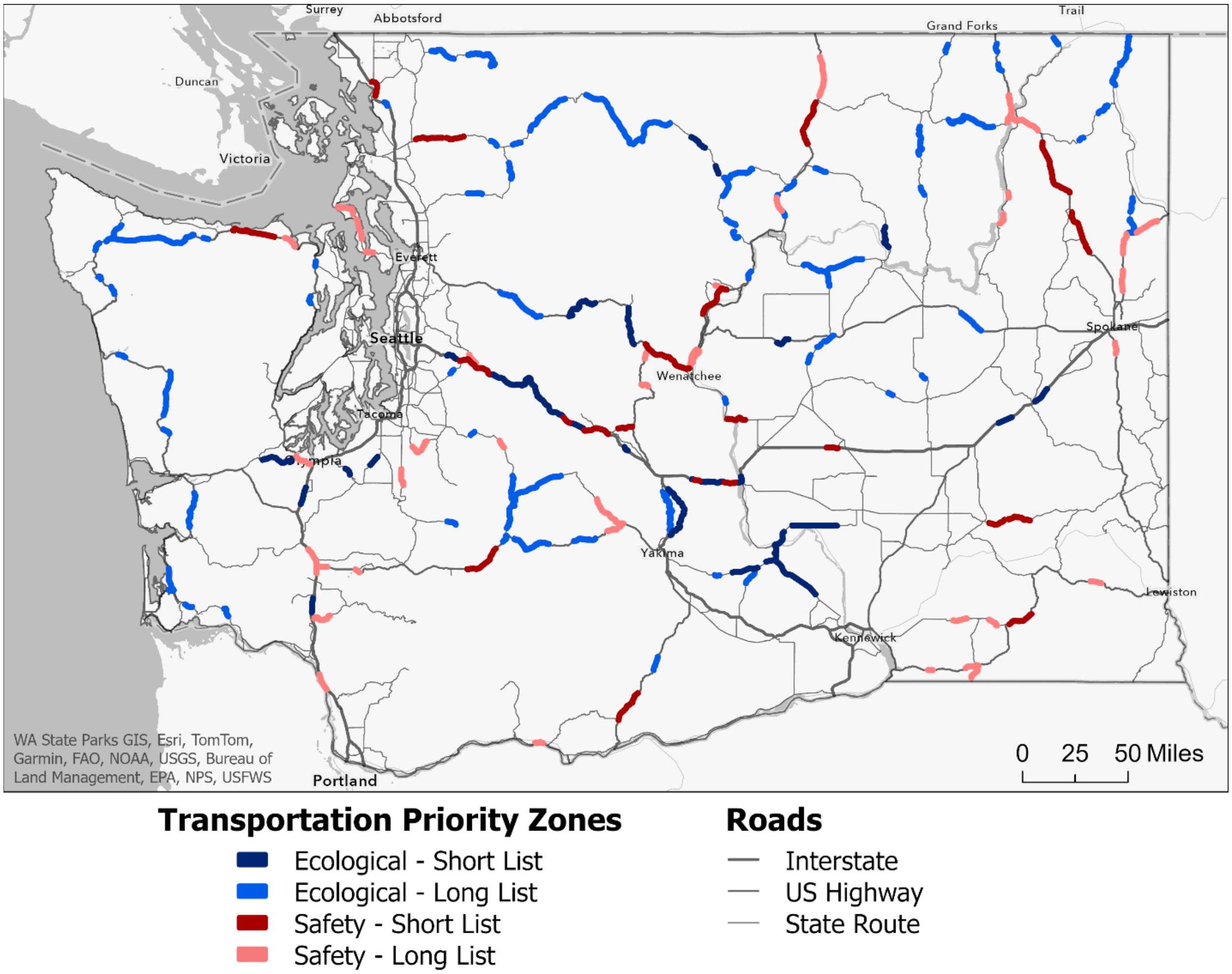

Figure 10. WAHCAP Transportation Priority Zones. This map shows the 96 Ecological Value Priority Zones (in blues) and 60 Wildlife-related Safety Priority Zones (in reds) that together make up the WAHCAP transportation analysis Long List. Darker shades represent segments included in the more selective Short List. These zones highlight highway segments where mitigation actions could significantly improve habitat connectivity and/or reduce wildlife-vehicle collisions.

Consideration of Scale and Notable Exceptions

Certain high-value locations, particularly smaller habitats beneficial for wildlife connectivity, were not identified as Priority Zones due to surrounding landscape conditions. In some cases, these areas may represent the last opportunities for connectivity between major regions but did not rank highly because of the broader scoring context.

For example, wildlife corridors identified in other analyses crossing US 12 east and west of Central Park did not consistently score high enough in either category to identify transportation Priority Zones in the WAHCAP. However, several one-mile segments in this stretch ranked high priority in the Full Highway System Rankings for both categories. Additionally, a wildlife corridor west of Oakville, identified through GPS-collared cougar movements, did not meet prioritization thresholds. This was due to the corridor's constricted nature (0.25 miles wide) and the relevant landscape units informing the transportation analysis including surrounding urban and developed areas, thus lowering its Ecological Value score.

These cases highlight limitations of the statewide scoring approach. To address them, we identified "notable exceptions"—locations flagged and verified through local ecological knowledge or direct wildlife movement observations—as important opportunities to enhance or maintain habitat connectivity. These areas still warrant attention and investment, particularly when they align with community priorities or planned transportation projects. These locations are described in the Southwest Washington and Olympic Peninsula Regional Connectivity Profile.

Statewide Landscape Connectivity Priorities

The WAHCAP landscape connectivity analysis identified and prioritized locations that support broad-scale ecological connectivity across Washington's diverse ecosystems. This assessment was based on four primary criteria:

1. Landscape connectivity functions and values
2. Network importance at a statewide scale
3. Protection status and management intent
4. Habitat conversion threat

Each criterion provides a lens through which to identify priority areas for connectivity conservation. The resulting maps are not intended to be a final or exhaustive designation of priority areas, but instead a flexible framework to support connectivity planning and decision-making across scales.

Prioritization criterion 1: Landscape connectivity functions and values.

The number of connectivity functions and values that a location provides is one indicator of its relative statewide connectivity priority. WAHCAP synthesized ten ecological data layers (Table 1) to produce a single continuous surface of connectivity value. Each one-square-mile pixel was scored based on the number and strength of key aspects of connectivity functions and values it provides—such as ecosystem permeability, focal species movement potential, climate resilience, and corridor proximity. Together, these individual input layers and the synthesized landscape connectivity values map represent Best Available Science (WAC 365-195-915) to identify the types of connectivity functions and values *at statewide and regional scales*.

The synthesized map identifies locations that support multiple connectivity functions and values, offering a relative measure of each pixel's importance within the statewide network. Locations with a higher number of overlapping functions and values are considered to have higher connectivity value, but this synthesis should not be interpreted as a definitive indicator of ecological condition. The map is a tool for comparison and prioritization rather than a final verdict on any given location's ecological significance. Importantly, each input layer reflects a distinct aspect of connectivity, and areas with lower composite scores may still support key functions—such as movement for specific species or seasonal dispersal—that are not fully captured by the overall score. To better understand the connectivity value of a location and how it may contribute to broader conservation goals, users are encouraged to explore the individual input data layers to understand the specific functions, values, and landscape characteristics present.

It is important to note:

- Scores are relative.
- High connectivity scores do not imply perfect ecological condition.
- Low connectivity scores do not imply a lack of connectivity functions or value; they may still reflect important localized or species-specific values.
- The synthesized landscape connectivity layer provides a holistic view while the individual layers offer more insights for site-level planning and interpretation.

Landscape connectivity hot spots

To identify areas of concentrated ecological connectivity, a cost-weighted kernel density approach was applied to the synthesized connectivity values map. This analysis produced a kernel density surface detecting areas of high connectivity value that are aggregated across the landscape. These landscape connectivity "hot spots" represent areas where multiple connectivity functions co-occur in close proximity.

Many of the landscape connectivity hot spots were located within major protected areas—such as national parks and forests—due to relatively intact native vegetation, low structural fragmentation, and favorable topographic conditions for wildlife movement (see prioritization criterion 3 below).

Prioritization criterion 2: Network importance at the statewide scale.

At the statewide scale, one of the central goals of WAHCAP was to identify and support large-scale habitat connectivity across Washington's major ecosystems. To accomplish this, the landscape connectivity conservation values input data and synthesized maps were used to visualize and understand the major pathways of statewide significance. These datasets enabled identification of broad ecological pathways that maintain functional movement and ecological processes across regional boundaries.

From this analysis, we delineated 12 **Connected Landscapes of Statewide Significance (CLOSS)**. These large-scale connected landscapes collectively provide comprehensive connectivity between and within the major ecological regions of the state (Figure 11).

Washington's major ecological regions include: the Olympic Peninsula; the Willapa Hills in the southwest; the Cascade Mountains—including temperate mesic (wet) forest on the west side of the Cascades, montane mesic (wet) forest along the Cascade crest, and montane dry forest on the eastside of the Cascades); the Rocky Mountains in the northeast; the Blue Mountains in the southeast; and the large remaining core areas of shrubsteppe that connect to the Yakima Firing Range and Training Center on the Columbia Plateau.

The 12 CLOSS identified here broadly represent the generalized movement pathways—depicted conceptually in WAHCAP maps using blurred directional arrows—rather than narrow or prescriptive corridors. These broad linkages reflect broad gradients in habitat permeability, topography, and ecological condition. Some of the identified connections, particularly in the Columbia Plateau where fragmentation is more pervasive, are currently tenuous and may require targeted restoration, land use coordination, or other interventions to achieve long-term functional ecological connectivity.

Additional **Connected Landscapes of Regional Significance (CLORS)** are smaller in scale and provide critical redundancy and resilience to the statewide connected landscapes network (Figure 11). While locally significant connected landscapes are not explicitly identified in this analysis, the spatial datasets developed through WAHCAP can serve as foundational inputs for fine-scale planning and designation of locally important connectivity pathways.

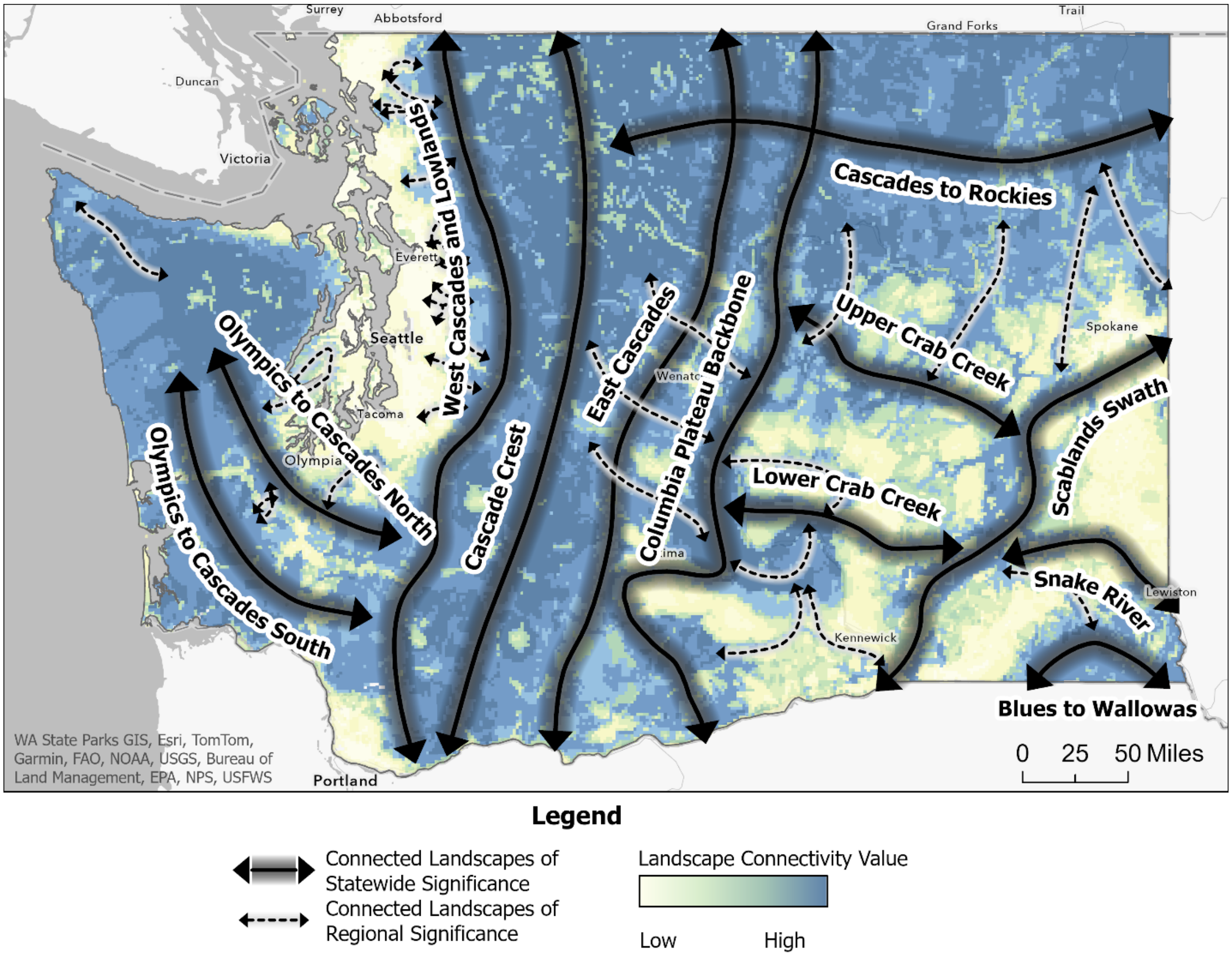

Figure 11. Connected Landscapes of Statewide and Regional Significance (CLOSS and CLORS). CLOSS are labeled.

Prioritization criterion 3: Protection status and management

Protected areas that are actively managed to sustain ecological functions and values form the backbone of a sustainable habitat connectivity network. In Washington, substantial portions of the landscape are owned and managed by public land agencies including but not limited to the National Park Service, the U.S. Forest Service, Washington State Department of Natural Resources, Bureau of Land Management, and WDFW. Many of these publicly managed lands were identified in the WAHCAP analysis as having high connectivity functions and values due to their extensive native vegetation cover, relatively low human modification, and role in linking ecological regions.

However, public ownership alone does *not* equate to permanent or consistently effective ecological protection. The conservation value of public lands depends on their underlying management mandates, land use allowances, and operational frameworks. Lands managed with biodiversity conservation as an explicit objective are more likely to retain their structural integrity and ecological function over time and are therefore prioritized in connectivity conservation planning. Other public lands, while not managed primarily for ecological outcomes, may still support key connectivity functions—such as movement corridors, stepping-stone habitat, or matrix permeability—depending on their specific land use practices.

Consequently, ***all public lands specifically managed to sustain biodiversity or protect habitat from conversion are identified as high priorities for protecting habitat connectivity functions and values***.

To evaluate conservation status, the Protected Area Database of the United Stated (PADUS v.4) data layer was used as the best available comprehensive spatial dataset of protected lands (Figure 12). Within this framework, lands are classified into GAP status codes based on their level of protection and land management objectives:

- **GAP 1**: Areas primarily managed for biodiversity, where natural disturbances are allowed or actively mimicked.
- **GAP 2**: Areas primarily managed for biodiversity, but natural disturbances may be suppressed.
- **GAP 3**: Areas are protected from land cover conversion but may be subject to extractive uses like logging or mining.
- **GAP 4**: Areas without any known biodiversity protection mandate.

For the purposes of this analysis, areas designated as GAP 1, 2, and 3 were considered "protected," acknowledging that the degree of ecological protection varies substantially across these categories. While PADUS represents the most complete publicly available source of conservation status information, it is not exhaustive. Through consultation with the TAG and expert reviewers, WAHCAP workshop participants identified notable omissions and inconsistencies within the dataset. Therefore, PADUS was used to provide a broad-scale overview of protected areas rather than a definitive or site-level assessment of land protection parcel status.

WAHCAP spatial data can be further used to evaluate how individual public land units contribute to statewide connectivity, considering both their structural condition and protection status. This information can help guide future investments in land protection, restoration, and stewardship to support a more resilient and connected ecological network.

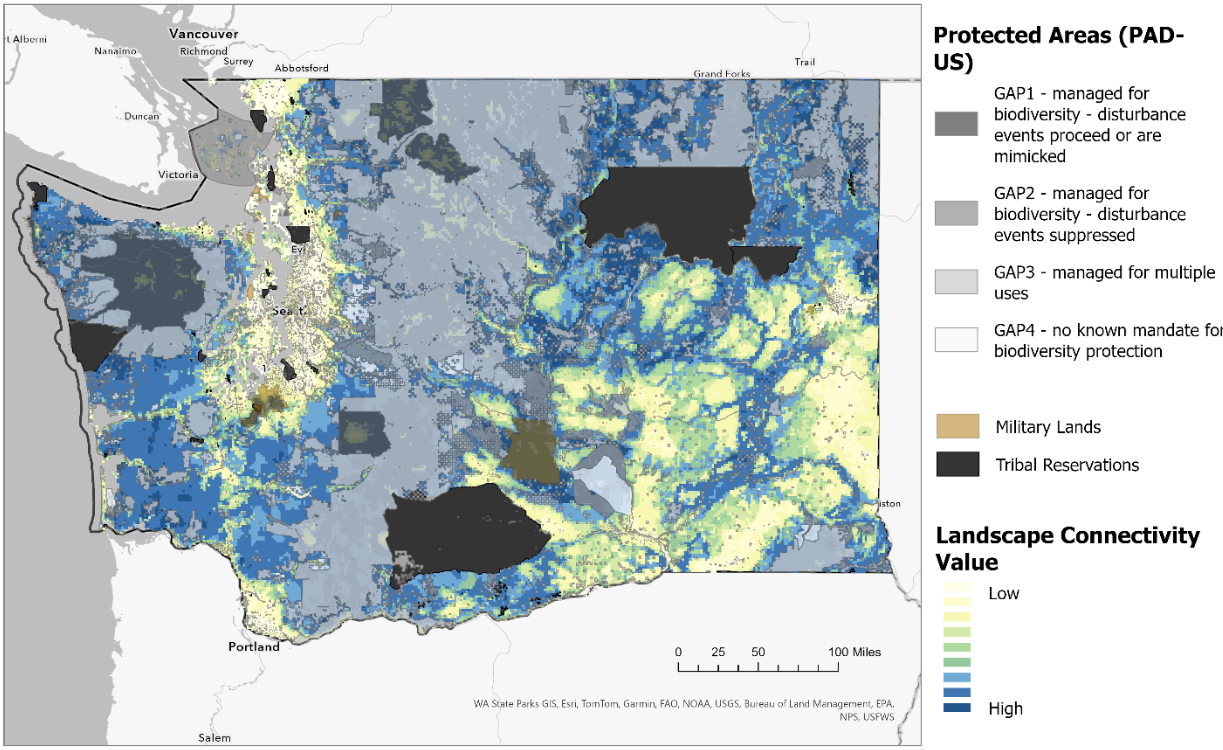

Figure 12. Protected lands (GAP 1-3) overlaid on landscape connectivity value.

Prioritization criterion 4: Habitat conversion pressure

Our final prioritization criterion focuses on quantifying habitat conversion pressure – or how vulnerable the habitat is to loss. Habitat loss and conversion can occur on both public and private lands and can stem from a wide variety of sources. Through webinar and workshop discussions with the TAG and IAG, the following key threats to habitat connectivity were repeatedly identified:

1. Transportation barriers.
2. Residential and commercial development.
3. Wind and solar energy development.
4. Recreation.

Through these discussions, we heard that agriculture and forestry land uses can have positive or negative impacts on habitat connectivity depending on how the lands are managed and how those activities are implemented. However, on the balance, the consensus was that agricultural and forestry lands provide a positive net-benefit for connectivity functions and values.

Wildfire was also identified as a driver of concern. However, wildfire impacts on connectivity are complex and dynamic over time compared to more permanent impacts from physical development. The TAG decided that core habitat areas that have burned should not be removed from core status because those areas recover over time.

Road and transportation barriers

See the transportation sections of the report for details on how this threat was analyzed and priorities for action.

All landscapes adjacent to transportation priorities (Full Highway System Rankings, Short or Long Lists) are a priority for landscape connectivity conservation. Road crossing structures will only be successful if wildlife have habitat on either side of the road to move between. Protecting and enhancing landscape connectivity leading to, across, and through the road crossing structures is essential for the crossing structure to function.

Residential and commercial development

We leveraged the time series data available through TerrAdapt's human footprint analysis to calculate an index of increase in human footprint score over the last 30 years due to residential and commercial development. This index was then multiplied with our map of connectivity values. We then used a cluster algorithm (cost-weighted kernel density approach) to identify development "hot spots" in areas with high connectivity values. This resulted in a map delineating areas with concentrations of high connectivity value which are also facing significant threat from potential residential and commercial development.

Wind and solar development

To identify connectivity areas with a high threat of solar development we used the Solar Development Suitability Model for Columbia Plateau created by a mapping group for the Least-Conflict Solar Project managed by Washington State University Energy Program (WSU 2023). This layer depicts the relative physical suitability for utility-scale, passive solar development. We then used a cluster algorithm (cost-weighted kernel density approach) to identify locations with high solar suitability and high connectivity values. The resulting layer assigned higher values to areas of high connectivity threatened by solar development. Due to time limitations, we were unable to conduct a similar analysis for wind energy development, but a similar analysis can be conducted with wind suitability data as a next step.

Recreation

Participants in our TAG, IAG, and Tribal workshops, voiced significant concerns about the impacts that recreational activities (e.g., hiking, biking, snowmobiles, off-road vehicles, and target practice) have on connectivity functions and values in Washington's public lands and particularly in the Cascade mountains. Significant recent increases in number of visitors to many areas has led to dramatic impacts on the ecological structure and function of these areas with particularly negative impacts on many wildlife species like elk.

TerrAdapt's human footprint model included impacts from recreation activities, including hiking and biking trails, campgrounds, backcountry campsites, ski areas, and resource roads that provide access to off-trail areas. These activities were represented in the model as site-level effects as well as distance effects radiating from the source to account for noise, light, invasive species, and other impacts. We heard differing perspectives in our TAG meetings about the relative impact of recreation activities per se, with some experts advocating for human footprint values associated with the features to be much higher and more similar to road and other human infrastructure. We tested different weights for the human footprint impact associated with recreation. However, we did not have access to or time to analyze actual recreational use data (i.e., visitation and use rates). Assigning high weights to recreation lowered the overall connectivity value of the Cascades. We felt this was an inaccurate representation of the very real recreational impacts because those impacts differ based on actual use, not the trail and campground infrastructure per se. Instead, we opted for a balanced approach where recreation impacts reduced habitat quality and increased resistance to movement, but not to a degree that would prevent areas from being included in Tier 1 core habitat or corridors.

Concurrent with WAHCAP development, the State-Tribal Recreational Impacts Initiative (STRII) convened to develop more sustainable, less impactful, and more culturally sensitive approaches to addressing recreational impacts and management strategies on state lands. STRII has contracted with the Conservation Biology Institute to develop spatial data to better represent recreational impacts on state lands. Data-sharing and coordination between STRII and WAHCAP will allow for mutually beneficial progress in mapping and addressing this significant and growing concern for habitat connectivity in the state.

Integrated habitat conversion pressure layer

We combined the data layers depicting high connectivity conservation values with those depicting high connectivity values under pressure from development and/or solar suitability (Figure 13). This map is intended to provide a high-level screening tool to identify to locations with generally high connectivity value that are experiencing development pressure and therefore warrant conservation attention. This map does not address all types of habitat conversion pressure, nor does it identify all locations at risk of conversion. At a fine scale, some locations identified on this map may have protection status not captured in our statewide data and therefore conversion risk may be overestimated.

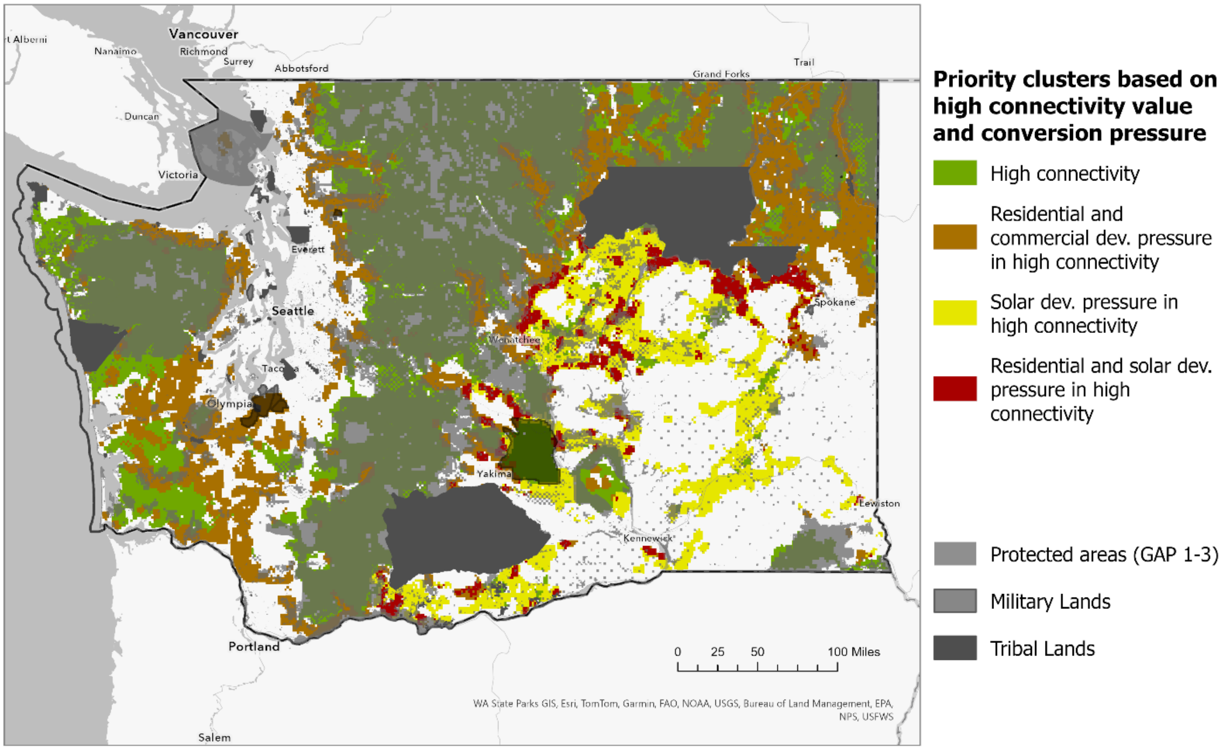

Figure 13. Integrated development pressure map showing areas where high habitat connectivity overlaps with residential and solar development pressure.

Implementation Strategies

Successful implementation of protecting and restoring habitat connectivity in Washington depends on mainstreaming connectivity considerations into existing planning, policy, and procedural frameworks at multiple jurisdictional scales. WAHCAP provides vital data, spatial priorities, and targeted strategies to support agencies, local governments, and private landowners in enhancing connectivity through established land-use planning processes, incentive programs, transportation infrastructure, and coordinated public land management.

How to use the maps to inform conservation

- Start with WAHCAP statewide data but then go back to original GIS data sources at original resolution
- Look for additional high quality/resolution local GIS data.
- If the local area is not showing up as a connectivity priority, look for opportunities to link into the priority network that has been identified.
- Riparian corridors are often useful links for connecting patches of protected lands.

Connectivity Planning at the Local Level

WAHCAP identifies critical factors to consider when prioritizing locations for habitat connectivity conservation action. These criteria are applicable at multiple scales, but the data and analyses presented here were done ***at the statewide and regional scales***. Locations with locally critical connectivity functions and values are not necessarily well represented in the associated spatial data but are crucially important in sustaining connectivity functions and values to support ecosystems and wildlife populations.

Most notably, connectivity functions and values in western Washington and the Puget Sound Trough are not well represented here. A critical next phase for WAHCAP is to identify finer-scaled habitat features such as locally significant habitat cores, steppingstones, riparian corridors, and other corridors in regions where large-scale cores and connections are lacking. This finer scale analysis is a necessary extension of the WAHCAP to achieve the full vision of identifying priority connectivity features that connect across major ecosystems in the state. Maintaining, enhancing, and restoring connectivity throughout the state is necessary even in regions lacking large habitat cores. In fact, those smaller habitat core areas can be even more critical to biodiversity structure and function because so little habitat is left in those regions.

Local connectivity analyses are the best tool for filling this gap. Statewide analyses identify broad priority regions, while local-based network studies dive deeper to delineate precise corridors and habitat areas. By integrating high-resolution local data and validating modeled links with empirical data, local analyses can ensure that mapped networks accurately reflect on-the-ground conditions. **Rather than being at-odds or duplicative, these multi-scale approaches reinforce one another: statewide plans set the big-picture framework, and local efforts translate those priorities into site-specific recommendations and projects.**

WDFW recommends that local jurisdictions reach out to WDFW for technical support to further identify local landscape connectivity priority locations. WAHCAP data can provide helpful information to start this process but will benefit from additional interpretation best done in collaboration with local governments. WDFW can provide technical support with the following next steps for local connectivity planning:

- Evaluate connectivity patterns and status in the county based on WAHCAP and other local data.
- Identify locations with statewide or regional significance.
- Identify locations with local connectivity significance not well represented at the statewide or regional scales.

- Explicitly consider riparian corridors and how these critical areas support connectivity in the County.
- Identify spatial data gaps where additional connectivity modeling at the local level could be needed.
- Assist in delineating distinct Biodiversity Areas and Corridors to incorporate into the WDFW Priority Habitats and Species program.
- Identify conservation strategies for specific locations based on connectivity characteristics and local land use policies and incentive programs.

The following case study provides an illustration of how connectivity modeling can be done at a local scale.

CALLOUT BOX: Whatcom County and Bellingham Wildlife Corridor Analysis: A Local Approach in Action

A prime example of effective local connectivity planning is from Whatcom County in northwestern Washington, where the City of Bellingham undertook a Wildlife Corridor Analysis in 2021. This effort highlights how a local approach can enhance statewide connectivity science. Notably, Bellingham's methodology was distinct from WAHCAP's approach, demonstrating that there are multiple scientifically valid ways to model and map connectivity.

Purpose and Scope: Bellingham's wildlife corridor analysis was initiated as part of the city's Urban Forestry Management Plan, with the goal of identifying important wildlife habitat "hubs" (core habitat areas), the corridors linking them, and any gaps or barriers to wildlife movement within the city limits and urban growth area. In contrast to a broad statewide analysis, this was a fine-scale, local study solely focused on the city and its immediate surroundings. The analysis built upon previous local habitat studies and was meant to guide on-the-ground actions in city planning and conservation.

Local Data and Focal Species: To achieve this fine-scale analysis the project team gathered extensive local data – for example, they used city-provided information on land cover and a newly developed 2021 forest structure layer—which detailed forest patch age, tree height, and structure—to map out habitat areas across Bellingham. Rather than treating all green space equally, each habitat patch received a quality score based on factors like proximity to urban development, signs of recent disturbance, and presence of riparian habitat.

Three focal wildlife species were selected to guide connectivity modeling. These species—northern red-legged frog, Douglas squirrel, and brown creeper—were chosen in consultation with city staff and local wildlife experts to represent a broad range of wildlife types and habitat needs in the area. The red-legged frog is an amphibian that relies on wetlands and nearby forests, the Douglas squirrel is a small tree-dwelling mammal needing contiguous forest patches, and the brown creeper is a songbird that lives in mature forests but can move through a patchy urban landscape. Together, they act as "umbrella" species for connectivity, each representing a guild of other species with similar movement needs.

Modeling Connectivity: Bellingham's approach used a network connectivity model called Conefor, a software tool that evaluates how connected habitat patches are, and identifies which patches or connections are most important for maintaining wildlife movement. First, habitat patches for each focal species were identified. "Links" were then created between patches –mapping where a frog or squirrel could reasonably move from one patch to another based on straight-line distance. With this habitat network, the model was then run to calculate connectivity metrics for each species by simulating patch removals and link enhancements to measure each element's impact. Results showed Douglas squirrel connectivity hinges on a few large coniferous patches—one acting as a keystone connector; brown creeper movement relies on many small urban woodlots as steppingstones; and red-legged frog dispersal is anchored in forest–wetland mosaics at the urban fringe.

Results and Local Application: This analysis created a Terrestrial Wildlife Habitat Network Map that delineates clusters of high-quality forest wetland "hubs", riparian areas, utility corridors, and strips of forest that link them. By overlaying the connectivity networks for all three focal species, the map highlights multi-species priority zones where maintaining tree cover, restoring vegetation, or adjusting road design will have the greatest impact on wildlife movement. This spatially explicit approach enables city and county planners to integrate connectivity into land-use decisions, park planning, and infrastructure projects—ensuring key routes/corridors remain open and development does not fragment or sever critical wildlife pathways.

The City of Bellingham analysis exemplified how local leadership can define ecologically meaningful, actionable connectivity boundaries. Using peer-reviewed methodology, the city tailored this network model to Bellingham's unique landscape, producing spatially explicit outputs that guide targeted actions.

This case study underscores a key message of the WAHCAP: statewide guidance is essential for identifying overarching goals and priorities, but local mapping turns those goals into on-the-ground reality, facilitating a connected Washington that reflects each region's ecological and community context.

Land Use Planning and Policy Integration

Habitat connectivity directly supports the goals of Washington's Growth Management Act (GMA) and comprehensive planning by promoting ecosystem resilience, biodiversity, and sustainable community development. With over 50% of the land in Washington in private ownership, cities and counties, working with their citizenry, have primary responsibility for planning where and how this land may be developed (Table 6).

Growth Management Act (GMA) Requirements: The GMA establishes a comprehensive framework for land-use planning and conservation in Washington, guiding jurisdictions to protect natural resources while accommodating sustainable growth. Comprehensive plans contain the local jurisdiction's long-range planning goals, policies and objectives. The plans set the direction for local land use planning, guide the day-to-day decisions of planning staff and elected officials, and are community driven. When a local jurisdiction updates their development regulations, they must be consistent with and implement their comprehensive plan.

Table 6. Land use planning and policy implementation actions.

Implementation Action	Tie to Habitat Connectivity	Key Implementer(s)
Establish Open Space Corridors • Identify and formally map open space corridors supporting wildlife habitat connectivity within and between urban growth areas (UGAs) • Integrate these corridors into official land-use and zoning maps	Establishing open space corridors ensures preservation of critical wildlife corridors, reduces fragmentation risks, and promotes safe wildlife movement across urban landscapes.	Local governments (cities/counties), Department of Commerce, WDFW
Integrate Habitat Connectivity into Comprehensive Plans • Explicitly incorporate habitat connectivity goals and policies into comprehensive plans • Use guidance tools such as the Department of Commerce Climate Guidance and Climate Policy Explorer • Engage WDFW regional staff for localized planning support and ecological guidance	Incorporating connectivity into comprehensive plans provides long-term, strategic alignment between growth management objectives and habitat conservation goals. This ensures explicit consideration of ecological connectivity and resilience in local planning frameworks.	Local governments (cities/counties), Department of Commerce, WDFW
Strengthen Critical Areas Ordinances (CAOs) • Explicitly incorporate habitat connectivity goals into CAOs	Strengthening CAOs to explicitly include connectivity objectives provides a legal and regulatory framework to protect essential wildlife	Local governments (cities/counties), WDFW (as technical guidance)

• Enhance protections for identified wildlife corridors and permeability in critical habitat areas	habitats and corridors, reducing habitat loss and fragmentation.	
Enhance Countywide Planning Processes (CPPs) • Standardize connectivity criteria across jurisdictions within counties • Integrate WAHCAP spatial data and priority corridors into countywide policies • Coordinate regional planning for consistent ecological standards to achieve landscape-scale connectivity	Enhancing CPPs promotes cohesive regional planning and alignment, ensuring that habitat connectivity considerations are consistently integrated into local and regional decision-making processes, ultimately supporting broader landscape connectivity goals.	County governments, regional planning councils, local governments, Department of Commerce, WDFW
Update Zoning and Subdivision Regulations • Update existing codes to include connectivity objectives. • Promote strategies such as clustered developments, conservation subdivisions, native vegetation, retention, and connectivity corridor overlay zones based on WAHCAP spatial priorities.	Updating zoning regulations minimizes habitat fragmentation by promoting development practices compatible with connectivity priorities identified by WAHCAP, directly supporting the conservation and restoration of critical wildlife habitats and movement corridors.	Local governments (cities/counties), WDFW (technical guidance)
Integrate Habitat Connectivity into Climate Resilience Strategies • Prioritize habitat connectivity as a climate adaptation strategy within comprehensive planning. • Ensure wildlife corridors are maintained to facilitate species adaptation to shifting climate conditions and preserve ecosystem resilience. • Ensure wildlife have movement options in the face of fires and flooding which are already occurring as the result of climate change.	Explicit integration of connectivity into climate resilience strategies supports species adaptation and ecosystem stability, enabling wildlife movement and genetic exchange necessary to adapt to climate-driven habitat shifts.	Local governments (cities/counties), Department of Commerce, WDFW, regional climate planning groups
Align with Riparian Standards and Salmon Recovery Efforts • Coordinate comprehensive plans with existing riparian protection regulations and salmon recovery frameworks. • Identify and protect riparian corridors that function as critical terrestrial and aquatic connectivity linkages.	Aligning riparian standards and salmon recovery efforts maximizes conservation outcomes by simultaneously protecting habitats essential for salmon populations and terrestrial wildlife movement, enhancing overall watershed connectivity and ecological function.	Local governments (cities/counties), salmon recovery Lead Entities, WDFW, Washington Recreation and Conservation Office (RCO), Department of Ecology

Voluntary Conservation Incentives for Private Landowners

Voluntary Conservation Incentives: Voluntary conservation incentives are essential tools for protecting and enhancing habitat connectivity across Washington's diverse landscapes (Table 7). Privately owned forested and agricultural lands often provide critical connectivity functions and values as many wildlife species comfortably move through these rural landscapes. Supporting private landowners to help maintain and enhance the connectivity functions they provide is key to achieving WAHCAP's connectivity goals. State and federal voluntary incentive programs encourage private landowners to adopt conservation practices by providing financial support, technical assistance, and guidance. WAHCAP implementation includes strategic coordination among agencies, local conservation districts, and non-governmental organizations to expand landowner participation and strategically align voluntary conservation actions with statewide connectivity priorities. Conservation districts are a critical resource for information and support to landowners about conservation incentive programs. The Cascades to Coast Landscape Collaborative's Conservation Program Explorer tool provides an additional resource to identity incentive programs available across the state and can support many of the implementation actions detailed below.

Table 7. Voluntary conservation incentive implementation actions.

Implementation Action	Tie to Habitat Connectivity	Key Implementer(s)
Target Natural Resource Conservation Service (NRCS) Incentive Programs in WAHCAP Priority Areas • Develop spatially explicit WAHCAP ranking criteria to integrate into NRCS conservation programs • Establish a gradient or binary scoring system for ranking applications based on their alignment with WAHCAP spatial priorities	Targeting NRCS voluntary conservation programs (Environmental Quality Incentive Program -EQIP, Conservation Stewardship Program - CSP, and Agricultural Conservation Easement Program-ACEP) to WAHCAP priority areas increases likelihood that incentive funding strategically supports connectivity priorities and habitat restoration by ensuring projects with higher connectivity value will score higher.	NRCS, WDFW
Target Landowner Outreach and Engagement • Identify and actively engage landowners within WAHCAP priority areas • Provide direct assistance to navigate complex incentive program applications, particularly for in-depth federal program applications	Reduces barriers to landowner participation, enabling increased adoption of conservation actions that directly benefit priority wildlife corridors and habitats identified by WAHCAP.	WDFW, NGOs, conservation districts, NRCS, Washington State Conservation Commission

Educate Landowners on Connectivity Benefits • Develop accessible outreach materials explicitly illustrating connectivity benefits of conservation practices • Utilize existing communication platforms, events, and agricultural extension services • Also provide materials for the public in these areas as to the benefits of landowner actions for connectivity, thus supporting landowners indirectly	Enhances landowner and nearby public understanding of connectivity, facilitating informed decision-making and encouraging voluntary adoption of connectivity-enhancing practices that benefit working lands and ecosystems.	WDFW, NGOs, Washington State Conservation Commission, conservation districts, agricultural extension
Train Agency and NGO Staff on Incentive Programs and WAHCAP Priorities • Conduct specialized training sessions for staff on federal and state voluntary incentive programs and their alignment with WAHCAP connectivity priorities • Equip staff to clearly articulate connectivity and support effective landowner engagement	Builds internal capacity, enabling agencies and NGOs to effectively communicate connectivity benefits and provide informed support to landowners, helping to ensure conservation actions align with WAHCAP priorities.	WDFW, NRCS, Washington State Conservation Commission, NGOs, conservation districts
Facilitate Connectivity-centric Incentive Program Applications • Provide direct technical assistance to landowners on framing voluntary conservation inventive program applications to highlight alignment with WAHCAP connectivity priorities • Ensure applications clearly articulate ecological and landscape-scale connectivity benefits	Enhances landowner competitiveness for voluntary conservation incentive program funding, directing resources toward high-priority connectivity areas identified by WAHCAP.	WDFW, WSDOT, local governments, Washington State Conservation Commission, NRCS, conservation districts, NGOs
Coordinate Conservation Across Jurisdictions • Establish collaborative planning committees, interagency agreements, or similar coordination mechanisms to align voluntary conservation actions strategically across jurisdictional boundaries • Ensure habitat conservation and restoration actions complement WAHCAP's connectivity objectives at a landscape scale • Establish a timeline framework for agency, NGO and landowner regular coordination meetings that also build trust among partners	Strengthens cross-jurisdictional collaboration, promoting more contiguous and cohesive habitat conservation efforts, essential for creating and maintaining seamless connectivity networks.	WDFW, Washington State Conservation Commission, NRCS, conservation districts, NGOs

Increase Technical Assistance Capacity • Expand and leverage existing technical assistance resources within NRCS, Washington State Conservation Commission, and local conservation districts • Increase, staffing, training, and resources to enhance direct support for landowners implementing connectivity-focused conservation practices	Increased technical assistance improves the adoption and effectiveness of conservation practices that benefit ecological connectivity, helping ensure sustained impacts on WAHCAP priority areas.	NRCS, Washington State Conservation Commission, local conservation districts, WDFW, NGOs

Transportation Infrastructure and Mitigation

Transportation infrastructure and traffic significantly influence wildlife habitat connectivity by fragmenting habitat, disrupting wildlife movement, and posing risks to both wildlife and motorists. Strategic actions—such as incorporating wildlife crossings into existing and planned transportation projects, retrofitting infrastructure to support wildlife movement, and enhancing interagency coordination—can mitigate these impacts (Table 8). The actions outlined below provide targeted, actionable recommendations to align closely with WAHCAP's connectivity priorities.

Table 8. Transportation infrastructure implementation actions.

Implementation Action	Tie to Habitat Connectivity	Key Implementer(s)
Integrate Wildlife Crossings into Transportation Planning and Projects • Include wildlife crossing considerations (e.g., overpasses and underpasses) during all planning phases of transportation infrastructure projects • Identify highway segments undergoing widening or improvements that align with WAHCAP priority areas to prioritize wildlife crossing installation	Incorporating wildlife crossings into highway widening and fish barrier removal efforts leverages existing infrastructure investments, enhancing habitat connectivity and reducing wildlife-vehicle collisions.	WSDOT, WDFW
Retrofit Existing Transportation Infrastructure • Assess existing infrastructure (bridges, culverts, underpasses) for retrofitting potential in WAHCAP priority areas	Retrofitting existing bridges, culverts, and underpasses enhances permeability for wildlife without the cost of new construction. WSDOT created a Passage Assessment System (PAS) in	WSDOT, WDFW

• Implement enhancements such as wildlife exclusion fencing to direct animals to existing structures and keep them from accessing the roadway, remove rip rap and blocking vegetation to create wildlife benches that allow for passage beneath bridges and culverts within priority areas.	2011 that can be used to make these assessments (Kitsch and Cramer 2011).	
Leverage Fish Barrier Removal Projects • Coordinate terrestrial wildlife connectivity projects in tandem with planned fish passage barrier removals within priority areas • Conduct joint terrestrial and aquatic connectivity assessments (e.g. WSDOT Habitat Connectivity Memos) early in the planning phases of fish barrier removal projects	Increasing terrestrial connectivity improvements within fish barrier removal projects maximizes the ecological benefits of existing investments.	WSDOT, WDFW
Support Standalone Wildlife Crossing Projects • Use the WAHCAP to identify locations to pursue grant funding for standalone wildlife crossing infrastructure in priority areas • Highlight and promote successful examples, such as the SR 20 Red Cabin Creek Wildlife Overcrossing led by the Stillaguamish Tribe of Indians, to build support and momentum for additional standalone projects	Pursuing standalone wildlife crossing projects addresses critical connectivity gaps identified by WAHCAP that may not align with ongoing or planned infrastructure projects.	WSDOT, WDFW, Tribal governments, NGOs
Enhance Cross-Agency and Cross-Jurisdictional Coordination • Establish interagency agreements to coordinate wildlife crossing planning and implementation across jurisdictions • Convene multi-agency groups, such as the Washington Wildlife Habitat Connectivity Working Group, that meet regularly to review transportation plans, connectivity priorities, and project opportunities	Improved coordination between transportation agencies, wildlife agencies, local governments, and tribes ensures comprehensive implementation of wildlife connectivity solutions across the transportation network.	WSDOT, WDFW, Tribal Governments, Local Governments, NGOs

Public Lands and Habitat Connectivity

Washington state contains extensive public lands, encompassing vast stretches of national forests, parks, wildlife areas, and other conserved spaces that support wildlife habitat and provide essential connectivity across landscapes. However, it would be erroneous to assume these lands are free from human impacts. Recreational pressure, legacy forest road networks, habitat fragmentation, and management inconsistencies across jurisdictional boundaries all present ongoing challenges to habitat connectivity on public lands in Washington. Addressing these issues through targeted management, cross-agency collaboration, and intentional planning is essential to ensuring these lands continue to serve as resilient, connected habitats for Washington's wildlife (Table 9).

Table 9. Public lands management implementation actions.

Implementation Action	Tie to Habitat Connectivity	Key Implementer(s)
Mitigate Recreational Pressure on Public Lands • Plan and zone recreation strategically within public lands, identifying low-impact areas for public use and protecting critical wildlife corridors through spatial zoning • Manage recreational use intensity and timing, establishing clear seasonal restrictions or timing limits (e.g., closures during critical breeding or migration periods) • Consolidate recreation use by establishing and clearly marking trails and recreational nodes, actively redirecting use away from sensitive habitats. • Restore and protect areas impacted by recreational pressures, including habitat restoration, trail closures, revegetation, and erosion control.	Strategically managing recreation is essential for maintaining habitat connectivity on public lands. As recreational use has significantly increased, particularly following the COVID-19 pandemic, sensitive wildlife habitats and corridors face growing disturbance. Implementing targeted strategies—such as carefully zoning recreational areas, managing timing and intensity of use, clearly marking designated trails, and restoring degraded habitats—can significantly reduce recreation-driven habitat fragmentation and wildlife disturbance. This ensures critical wildlife corridors remain effective, sustaining landscape-scale connectivity across public lands.	WDFW, WDNR, State Parks, Tribes, Washington's State-Tribal Recreation Impacts Initiative (STRII), USFS, NPS, BLM, Local Governments
Forest Road Decommissioning and Access Management • Prioritize road removal or decommissioning in key connectivity zones identified by WAHCAP, targeting	Reducing road networks on public lands through targeted road removal, retrofitting essential roads, and managing access restrictions directly enhances habitat connectivity. These actions reduce habitat fragmentation, improve landscape permeability,	USFS, WDNR, BLM, WDFW, Local Governments

redundant and legacy logging roads to increase landscape permeability • Upgrade and retrofit essential roads (e.g., culvert replacement, adding wildlife crossings or fencing) to mitigate their impacts on wildlife • Implement seasonal or permanent road closures and access restrictions to reduce wildlife disturbance during critical lifecycle events (e.g., breeding, migration) • Regularly maintain and monitor essential roads for wildlife permeability, including monitoring wildlife use of crossings and identifying further road mitigation needs	and facilitate wildlife movement across public landscapes.	
Enhance Cross-agency Coordination and Planning • Establish formal interagency working groups specifically focused on coordinating habitat connectivity actions across jurisdictions. • Pursue cross-boundary planning and implement joint habitat connectivity projects, facilitating continuity of WAHCAP wildlife corridors across jurisdictional boundaries. • Identify and mitigate edge effects through buffer creation, compatible land-use practices, and habitat restoration along jurisdictional boundaries • Conduct regional-scale connectivity planning to systematically integrate habitat connectivity into regional conservation strategies and comprehensive plans	Explicitly integrating habitat connectivity into land management plans ensures that connectivity objectives become central to management actions. This alignment promotes coordinated, effective habitat conservation across public lands, securing long-term ecological resilience and facilitating wildlife movement across jurisdictional boundaries.	WDNR, USFWS, WDFW, State Parks, USFS, BLM, US NPS, Local Governments

Integrate Habitat Connectivity into Land Management Plans • Embed habitat connectivity priorities explicitly within Habitat Conservation Plans (HCPs) and state trust land policies, ensuring habitat connectivity becomes a core component in land-use planning. • Integrate habitat connectivity objectives into Wildlife Area Management Plans and Park Management Plans, clearly identifying and managing wildlife connectivity.	Explicitly embedding habitat connectivity in land management plans ensures connectivity becomes central to decision-making, directly guiding conservation priorities, resource allocation, and on-the-ground management actions to maintain intact, resilient wildlife corridors.	WDNR, USFWS, WDFW, State Parks, USFS, BLM, Local Governments

CALL OUT BOX 1: ALIGNMENT OF VOLUNTARY CONSERVATION INCENTIVES WITH WAHCAP CONNECTIVITY PRIORITIES

Voluntary conservation incentive programs, including federal programs such as the Environmental Quality Incentives Program (EQIP), Conservation Stewardship Program (CSP), Agricultural Conservation Easement Program (ACEP), and related state and local conservation initiatives play critical roles in supporting the habitat connectivity objectives outlined in WAHCAP.

These programs can specifically be guided by WAHCAP's spatially explicit data and prioritization maps, which identify locations of significant landscape connectivity value throughout the state. By using WAHCAP data, conservation incentive programs can strategically focus their outreach, prioritize their funding allocations, and streamline application processes toward projects located in areas identified as essential to maintaining or restoring ecological connectivity.

WAHCAP can also serve as a foundational resource for landowners. By clearly illustrating how participation in voluntary inventive programs contributes directly to broader habitat connectivity objectives, WAHCAP facilitates informed decision-making by landowners. This alignment helps landowners appreciate their property's ecological role within the broader landscape context and motivates participation by highlighting both the connectivity and potential economic benefits of working lands.

The intersection of voluntary conservation incentive programs and WAHCAP connectivity priorities ensures strategic spatial alignment, more efficient resource allocation, increased landowner participation, and more comprehensive landscape-scale conservation. Table 10 outlines some of those nexus points of voluntary conservation incentives and WAHCAP.

Table 10. This table outlines specific opportunities for aligning voluntary conservation incentive programs with the habitat connectivity objectives in WAHCAP. It highlights applicable incentive programs, mechanisms to strategically integrate WAHCAP data and priorities, and the resulting ecological benefits for habitat connectivity in Washington.

WAHCAP Connectivity Objective	Applicable Incentive Programs	Mechanism for Alignment	Habitat Connectivity Outcome
Core habitat conservation and restoration	ACEP, Forest Legacy, Farmland Preservation Grants	Protect high-value lands through easements based on WAHCAP core habitat maps.	Permanently secures crucial habitat cores, maintaining essential biodiversity refuges and sources for wildlife populations.

Wildlife corridors and linkages	EQIP, CSP, CRP, Riparian Buffer Grants, local conservation easements	Prioritize funding and project selection criteria to focus on identified corridors from WAHCAP spatial priorities.	Enhances landscape permeability, reducing fragmentation and allowing safe wildlife movement across landscape.
Private lands stewardship	CSP, EQIP, Working Lands for Wildlife, Sustainable Certification (FSC, SFI)	Align working land management practices (e.g., habitat enhancements, riparian buffers, sustainable forestry) with WAHCAP connectivity maps.	Improves habitat quality and ecological connectivity on working lands, balancing productive land use with ecological benefits.
Cross-jurisdictional coordination	NRCS partnership programs (RCPP),	Use WAHCAP spatial data as a shared prioritization tool across multiple agencies and jurisdictions to coordinate incentive efforts.	Connected landscape conservation projects, linking ecological impacts across jurisdictions and leveraging cross-agency resources.
Landowner education and engagement	NRCS technical assistance, Conservation Districts, NGO outreach	Use WAHCAP maps and priorities to educate and guide landowner participation in conservation incentives.	Increases landowner awareness and active stewardship, ideally translating into on-the-ground connectivity actions.

Callout Box 2: State-Tribal Recreation Impacts Initiative (STRII)

Washington's State-Tribal Recreation Impacts Initiative (STRII) is a collaborative effort among Washington state natural resource agencies (WDFW, Department of Natural Resources, State Parks, and the Recreation and Conservation Office) and Washington's Tribal Nations. Established in 2023, in response to increased recreational pressure on public lands, STRII aims to improve recreation management practices to safeguard ecological integrity and protect culturally significant areas, while respecting and centering Tribal treaty rights and obligations.

STRII directly intersects with WAHCAP's habitat connectivity goals by addressing recreation as an emerging threat to wildlife movement. Increasing recreational pressures, especially since the COVID-19 pandemic, have impacted wildlife corridors, disturbed sensitive species, and disrupted habitats in locations identified as high priorities for Statewide connectivity (Nelson and Bailey 2021). For example, substantial portions of the Cascade Range emerged from WAHCAP analyses as critical to statewide habitat connectivity, with broad habitat extent and limited development, yet these same regions have also seen marked increases in recreational pressure. Research from across the Northwest indicates that both motorized and non-motorized recreation disrupt wildlife movement and activity patterns, while well-managed recreation along designated routes concentrates the impacts to limited areas (Nelson and Bailey 2021, Sytsma et al. 2022, Gump and Thornton 2023).

This first iteration of WAHCAP did not explicitly incorporate recreation impacts into the connectivity analyses, underscoring the value of initiatives like STRII that gather critical data to fill these knowledge gaps. Moving forward, the WAHCAP team will support STRII by:

- **Providing relevant ecological and spatial data** from WAHCAP analyses to inform STRII's evaluation of recreation impacts.
- **Collaborating on data collection and sharing** efforts to better quantify the ecological impacts on wildlife connectivity.
- **Integrating STRII fundings into future WAHCAP updates** of connectivity prioritization to refine and improve habitat conservation strategies.
- **Supporting the development of targeted management actions** and best practices that balance recreation with habitat protection and connectivity.

Through these collaborative actions, WAHCAP and STRII can jointly advance solutions that balance recreation with the maintenance and expansion of wildlife connectivity and ecological resilience across Washington.

Future Research and Analysis

One of the guiding principles for the WAHCAP was to focus on action not analysis, to use and refine existing data to identify priorities despite having gaps in our knowledge. The WAHCAP is a living document and will be updated as new information becomes available. We have identified the following areas to focus ongoing research and analyses for future iterations of the WAHCAP:

- **Improved Focal Species Models and Validation:** Many of the focal species models included in the WAHCAP are over a decade old and were based on expert knowledge of the species' habitat and movement needs. Where possible, future versions of the WAHCAP should incorporate empirical movement data to develop new focal species models and/or validate existing models.
- **Finer Scales:** The WAHCAP is best suited for supporting statewide and regional planning but falls short identifying local priorities within cities and counties. Relative to the statewide connectivity network, habitat within more developed settings appears to have little value in the WAHCAP statewide products, but this remaining habitat can have tremendous local importance. To support users working at these scales, we have provided the WAHCAP input GIS datasets at their original resolution that users can apply to their own geographies and WDFW can provide technical assistance to help jurisdictions identify local finer scale data and connectivity priorities at the local scale. In the future the WAHCAP should work to better bridge the gap to local scales.
- **Riparian and Wetland Habitats:** These habitat types are not well-represented in the WAHCAP. Riparian habitat in particular presents valuable opportunities for habitat and climate connectivity because it creates a linear network across the landscape linking lower to higher elevations. Riparian habitat is also largely already protected under Washington's existing regulatory framework (i.e., Growth Management Act [GMA], Forest Practices Rules, etc.). We attempted to incorporate riparian habitat from multiple datasets but ran into challenges related to the spatial scale of riparian habitat relative to the scale of the statewide analysis (one-mile pixels), the relative importance of riparian habitat to habitat connectivity in dry (e.g., shrubsteppe) vs. wet (e.g., southwest Washington) habitats, and assessing the condition of riparian habitat. Incorporating wetland habitats in the future will help identify connectivity options for species like amphibians that are dependent on wetlands for all or part of their life cycle.

- **Prairie Habitats:** Washington's prairies were not one of the ecosystems selected for ecosystem connectivity modeling for the WAHCAP. Limited time and funds necessitated focusing on the most widespread ecosystems in the state, however Washington's prairies are important, threatened, and incredibly biodiverse. After receiving stakeholder feedback we added a data layer for Westside Prairie habitat based on soil type, the human footprint, and absence of trees, but this layer should be improved for future versions. Palouse prairie in eastern Washington is not represented in WAHCAP and should be added for future versions.
- **Recreation:** Recreational activities (e.g., hiking, biking, snowmobiles, and off-road vehicles) are having significant impacts on connectivity functions and values in Washington's public lands and particularly in the Cascade mountains. Concurrent with the WAHCAP, the State-Tribal Recreational Impacts Initiative (STRII) has convened to develop more sustainable, less impactful, and more culturally sensitive approaches to addressing recreational impacts and management strategies on state lands. STRII is developing spatial data to better represent recreational impacts on state lands, which should be incorporated into WAHCAP in the future.

Regional Connectivity Profiles

These regional connectivity profiles provide detailed descriptions of ecological conditions, threats to habitat connectivity, and targeted conservation strategies for specific geographic areas within Washington. Each regional profile centers data that was developed by the WAHCAP, but **we emphasize the necessity of revisiting original data sources at their highest resolution to inform local conservation decisions effectively.**

While the WAHCAP highlights many critical statewide priority areas, it is important to recognize there are numerous additional local and regional habitats not explicitly identified as WAHCAP priorities. The absence of specific areas from these summaries does not imply a lack of ecological value or local or even regional priority status. Conservation planners and practitioners should actively seek out and incorporate additional high-quality, high-resolution local data sources to complement and enhance statewide connectivity analyses.

Riparian corridors warrant special mention. Riparian corridors are valuable ecological connectors that are used as travel corridors for many species and provide natural climate corridors that connect low to high elevation habitat. Riparian corridors are especially important in highly fragmented or urbanized landscapes and should be prioritized as key conservation and restoration opportunities. We were not able to represent riparian areas well at the statewide scale because riparian zones are narrow relative to the scale used here but also pervasive throughout Washington.

Cascades

The Cascades is a mountainous and largely forested region following the Cascade Mountain range, extending across the Canadian border in the north through North Cascades National Park, Mount Baker-Snoqualmie National Forest, Okanogan-Wenatchee National Forest, and Mountain Rainier National Park, southward towards the Columbia River Gorge and into Oregon. The landscape is characterized by volcanoes, glaciers, and snow-fed rivers. The western slopes of the Cascades support mesic coniferous forest, while dry forests cover the eastern slopes due to a rain shadow effect. Subalpine and alpine habitat occur at high elevations along the crest.

The Cascades represent Washington's largest contiguous area of intact forest, forming a critical Connected Landscape of Statewide Significance across elevational and latitudinal gradients. The region harbors numerous species of conservation concern and provides core habitat for a wide range of priority and focal species in Washington. Species of conservation or cultural significance include but are not limited to mule deer (*Odocoileus hemionus*), elk (*Cervus elaphus*), black bear (*Ursus americanus*), bighorn sheep (*Ovis canadensis*), mountain goat (*Oreamnos americanus*), cougar (*Puma concolor*), lynx (*Lynx canadensis*), wolverine (*Gulo gulo*), pika (*Ochotona princeps*), Cascade red fox (*Vulpes vulpes cascadensis*), northern spotted owl (*Strix occidentalis caurina*), marbled murrelet (*Brachyramphus marmoratus*), and western toad (*Anaxyrus boreas*). Because it links habitats along both an elevational and north-south gradient, the Cascades are a critical pathway for climate connectivity at a continental scale (Carroll et al. 2018) and have been identified as a national priority for connectivity conservation by multiple independent scientific analyses (Dreiss et al. 2024).

The Cascades are bisected by six state highways: State Route 20 (SR 20), US Highway 2 (US 2), Interstate 90 (I-90), State Route 410 (SR 410), US Highway 12 (US 12), and State Route 14 (SR 14), listed from north to south. Priority Zones were identified for each, but I-90 and US 2 are the highest transportation priorities for this region in terms of increasing the permeability of the roadway to animal movements. Due to substantial traffic in this region, I-90, with an AADT of 38,282, is considered a complete barrier without safe crossing opportunities. US 2, though lower in traffic volume (7,389 AADT), also creates substantial barriers to movement for many species.

I-90 Snoqualmie to Snoqualmie Pass *Eco*, and I-90 Snoqualmie Pass to Cle Elum *Eco*; as well as US 2 Steven's Pass Vicinity and US 2 Nason Creek to Leavenworth were identified as

Ecological Value Priority Zones. Notably, both I-90 Ecological Value Priority Zones also overlap with Wildlife-related Safety Priority Zones.

The I-90 Snoqualmie to Snoqualmie Pass *Eco* Priority Zone overlaps with I-90 Snoqualmie to Snoqualmie Pass *Safety* Priority Zone just outside of North Bend—one of the top four elk-vehicle collision locations statewide. Similarly, the I-90 Snoqualmie Pass to Cle Elum *Eco* Priority Zone overlaps I-90 Snoqualmie Pass to Cle Elum *Safety* Priority Zone in two locations between Roslyn and Cle Elum, driven by wildlife-vehicle collisions involving deer, elk, and black bears.

Three of the four worst elk-vehicle collision locations in the state occur within the Cascades. In addition to the I-90 Priority Zone outside North Bend, SR 20 Skagit Valley West and SR 20 Skagit Valley East Wildlife-related Safety Priority Zones—considered one Priority Zone on the Short List—are also high risk areas. This section of SR 20 lies within the core home ranges of four distinct elk sub-herds (Nooksack Elk Herd) resulting in four distinct collision hot spots (Sevigny et al. 2021).

The Stillaguamish Tribe of Indians was awarded federal funding through the Wildlife Crossings Pilot Program (WCPP) and is leading a wildlife overcrossing project within the Skagit Valley West Priority Zone to significantly reduce elk-vehicle collisions.

The US 12 Packwood Vicinity Priority Zone also ranks among the top four worst elk-vehicle collision locations. The Puyallup Tribe of Indians received WCPP funding to conduct a wildlife crossing structure feasibility study in this Priority Zone, which is currently underway. The study aims to identify ideal locations for wildlife crossings to significantly reduce elk-vehicle collisions and improve connectivity for a broad diversity of rare and at-risk species.

Figure 14 shows connectivity priorities and Table 11 summarizes key threats and conservation opportunities in the Cascades Region.

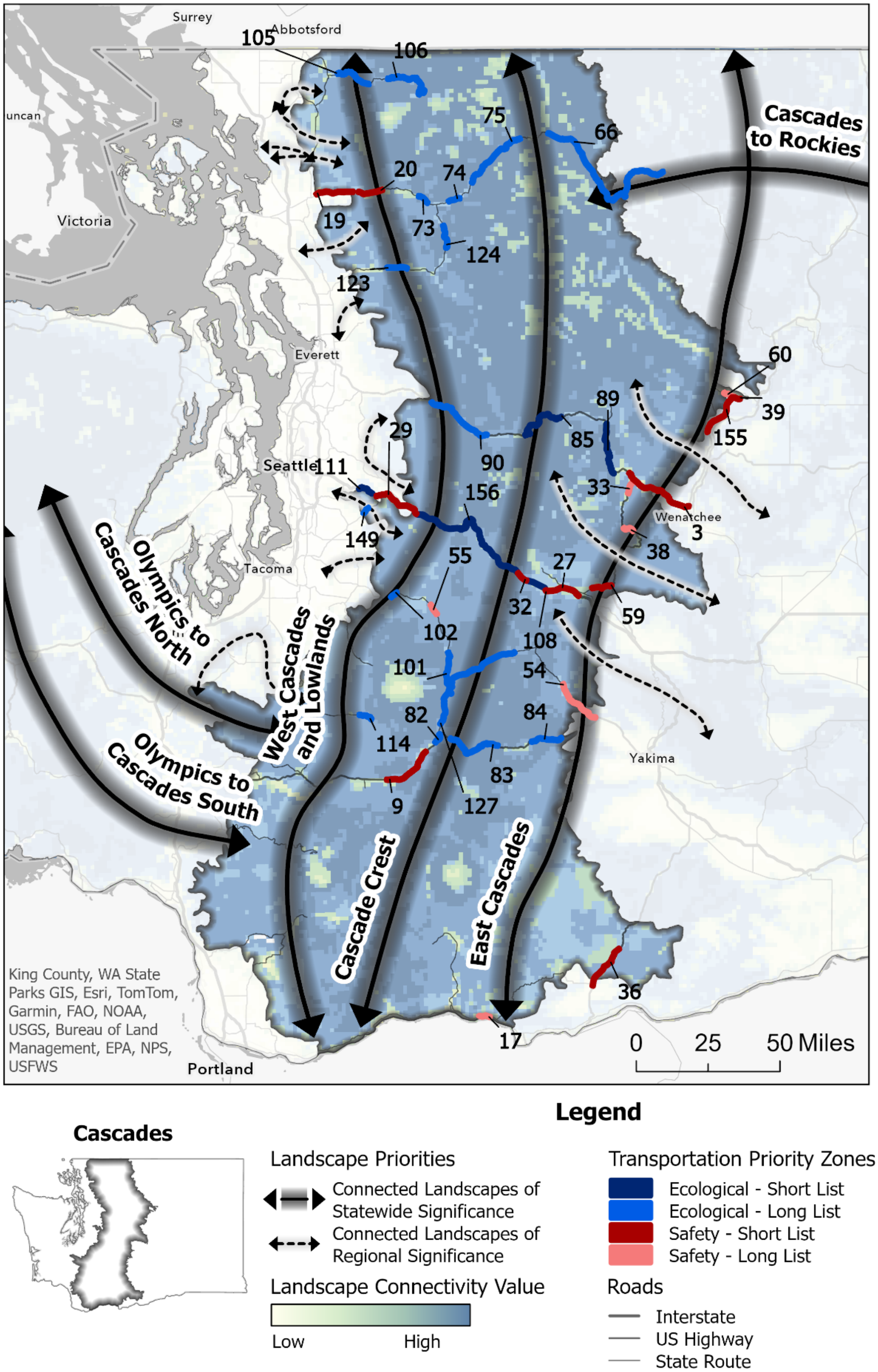

Figure 14. Landscape and transportation connectivity priorities in the Cascades. Label numbers for transportation priorities are for reference and do not reflect priority.

Table 11. Key threats to ecological connectivity in the Cascade Crest Region and corresponding conservation and restoration opportunities aimed at maintaining and enhancing habitat connectivity and wildlife movement.

Threats to Connectivity	Conservation & Restoration Opportunities
Transportation Infrastructure: Major highways (I-90, US 2, US 12, SR 20, SR 410 and SR 14) bisect core areas creating barriers to connectivity and wildlife-vehicle collision hot spots. Increased development along these highways impacts ecological integrity.	**Wildlife Crossings:** Implement wildlife crossings and road mitigation measures along highways to restore habitat connectivity between core areas and reduce wildlife-vehicle collisions. **Aquatic and Terrestrial Project Integration:** Pair terrestrial wildlife connectivity considerations with aquatic fish passage remediation projects to achieve comprehensive ecological benefits.
Increasing Recreation Pressure: Rapid growth in outdoor recreation increases traffic volume on major highways and intensifies ecological impacts of recreation, particularly within national forests.	**Manage Recreation:** Collaborate with public land managers to strategically manage recreational access, minimizing ecological disturbances.
Resource Road Networks: Extensive networks of resource extraction roads within public forest lands fragment and degrade habitats.	**Road Network Management:** Work with public land managers to reduce negative impacts from resource extraction and associated road networks through selective decommissioning and restoration.
Increasing Risk of Wildfire: Climate change and historical fire suppression practices have lead to larger and more severe wildfires, especially in east-side dry forests.	**Wildfire Risk Reduction:** Integrate ecological connectivity goals into wildfire risk management strategies, promoting forest resilience and reducing wildfire severity.
Development Near Public Lands: Development adjacent to public lands	**Development Planning:** Engage in land-use planning and management strategies for private lands adjacent to

increases habitat fragmentation and edge effects, threatening habitat connectivity.	public lands to minimize fragmentation, edge effects, and maintain connectivity.

Additional Resources

- **WSDOT Snoqualmie Pass East Project**: Project overview and performance of the Snoqualmie Pass East wildlife crossings along I-90.
- **Red Cabin Creek Wildlife Overpass Project**: A project led by the Stillaguamish Tribe and funded by the federal Wildlife Crossings Pilot Program to construct an overpass over SR 20 in the north Cascades.
- **US 12 Wildlife Crossing Structure Feasibility Study** (bottom of page)**:** A project led by the Puyallup Tribe and funded by the federal Wildlife Crossings Pilot Program to identify ideal locations for wildlife crossings on US 12 in Packwood vicinity.
- **Cascadia Partner Forum**: A network of conservation practitioners working in Washington and British Columbia's Cascade Mountains to build a resilient landscape for the region's fish, wildlife, and people.

Southwest Washington and Olympic Peninsula

Southwest Washington and the Olympic Peninsula are home to diverse landscapes, including the floodplains of the Chehalis and Cowlitz Rivers, extensive prairies and oak savannas, the Olympic Mountains, Willapa Hills, and foothills of the south Cascades. The region covers the Olympic Peninsula and extends to portions of the southern Cascades. The Willapa Hills primarily consists of private timberlands, creating a dynamic of mixed-age forest stands. Historically rural, this area is experiencing rapid residential and commercial development along Interstate 5 (I-5) and other major highways. The Olympic Peninsula features the Olympic Mountains and coastal habitats, with the central region of the Olympic Mountains protected as Olympic National Park and Olympic National Forest. These public lands are surrounded by extensive areas managed by Tribes and state agencies, providing large areas of diffusely connected habitat for wildlife. The eastern edge of the southwest Washington and Olympic Peninsula region extends into the core habitats of the Cascades.

I-5 runs from the Oregon State border at Vancouver, north through the Puget Sound region, to the Canadian border at Blaine, and serves as a complete barrier to wildlife in most instances (95,325 AADT across its entire length), cutting off the Olympic Peninsula and Willapa Hills from the rest of Washington (86,600 AADT in this region). US 12 runs east-west across the Olympic Peninsula, extending from Aberdeen east to Grand Mound, recording approximately 14,676 AADT (range 5,900 to 24,000 AADT). State Route 8 (SR 8) begins at the

US 12 junction in Elma and extends east to Olympia, recording 19,381 AADT; together, US 12 and SR 8 effectively bisect the Olympic Peninsula and create significant barriers to wildlife movement. Development occurring alongside these highways further exacerbates habitat fragmentation. *Protecting and restoring habitat connectivity across these fracture zones is a critical priority for this region.*

Historically maintained by indigenous land management practices, notably indigenous burning, the river valleys in this region support prairies and Oregon white oak savannas, habitat for a number of unique species of conservation concern including Mazama pocket gopher (*Thomomys mazama*), western grey squirrel (*Sciurus griseus*), streaked horned lark (*Eremophila alpestris strigata*), Oregon vesper sparrow (*Pooecetes gramineus affinis*), and multiple butterfly species including Taylor's checkerspot (*Euphydryas editha taylori*). Outside of these isolated prairies and oak woodlands, the region is characterized by the mostly conifer-dominated and more mountainous regions of the Olympics, Willapa Hills, and south Cascades. Species of conservation and/or cultural significance include but are not limited to elk, Columbian white-tailed deer (*Odocoileus virginianus leucurus*), black-tailed deer (*Odocoileus hemionus columbianus*), black bear, cougar, fisher (*Pekania pennanti*), northern spotted owl, marbled murrelet, Oregon spotted frog (*Rana pretiosa*), western toad, and numerous salamanders.

The Olympic Peninsula is surrounded by water on three sides, with the Columbia River forming an additional east-west barrier along Washington's southern border with Oregon. These natural barriers, combined with transportation barriers like I-5 (north-south) and US 12/SR 8 (east-west), significantly restrict wildlife movement into and out of the Olympic Peninsula. This fragmentation threatens landscape-level connectivity between the Olympic and Cascade Mountain ranges. For example, cougar populations west of I-5 exhibit the lowest genetic diversity in the state and the highest rates of inbreeding – evidence of the barrier effect imposed by I-5, even on even the most mobile species in this region (Zeller et al. 2022; Wultsch et al. 2023).

Four Transportation Priority Zones emerge as top priorities in this region: three Ecological Value Priority Zones and one Wildlife-related Safety Priority Zone. I-5 is one of the greatest barriers to wildlife movement in the state. Multiple analyses, including the WAHCAP, identify two remaining opportunities to restore connectivity across this fracture zone: the I-5 Northern Linkage Zone and I-5 Southern Linkage Zone, both on the Short List. Improving connectivity in these areas would restore connection between the Olympic Peninsula, Willapa Hills, and South Cascades – enhancing genetic diversity for cougars and other species. Cougar presence has been repeatedly documented directly adjacent to I-5 in both linkage zones using remote cameras and GPS collars. However currently, safe crossing opportunities remain limited.

The SR 8 McCleary to US 101 Priority Zone works in tandem with the I-5 Northern Linkage Zone to facilitate wildlife movements from the Olympic Peninsula, across SR 8 into Capitol State Forest (a 100,000-acre core area), and onward across I-5 into the Cascades (part of the Olympics to Cascades North CLOSS). The permeability of SR 8 has improved substantially in recent years as many fish barrier culverts have been replaced with fish and terrestrial wildlife-passable structures. In the I-5 Northern Linkage Zone, the Beaver Creek culvert—currently a fish passage barrier—will be replaced by a 75 ft span bridge underpass. While this upgrade will provide substantial benefits, additional structures are needed to fully restore connectivity across I-5 in the Northern Linkage Zone. In contrast, the I-5 Southern Linkage Zone currently has fewer options and will ultimately require standalone wildlife crossing structures. A feasibility study completed in November 2024 identified optimal wildlife crossing locations and structure types for both I-5 Priority Zones in this region. However, further design and construction are currently unfunded.

The US 101 Port Angeles to Sequim Wildlife-related Safety Priority Zone ranks among the highest deer-vehicle collision areas in western Washington. Over a five-year period, this 15-mile-long stretch recorded 224 deer carcass removals—including within downtown Port Angeles. Three fish barrier removal projects in this Priority Zone will be sized for deer passage (Tumwater, Ennis, and Lees Creeks). Once constructed, the addition of wildlife barrier fencing is expected to significantly reduce deer-vehicle collisions—although fencing is not currently funded.

While not identified as Priority Zones, there are two notable exceptions in this region, both on US 12.

1. **US 12 between Aberdeen and Elma, in the vicinity of Central Park**.
   Previous analyses, including the Cascades to Coast Analysis, identified two narrow bands of habitat that cross US 12 east and west of Central Park. These corridors – only one to two miles wide – are threatened by rapid development. Because these segments were small and disconnected, these areas did not score high enough in the WAHCAP analysis to identify distinct Ecological Value Priority Zones. However, multiple individual one-mile segments in this area ranked high priority in both the Ecological Value and Wildlife-related Safety Full Highway System Rankings. These represent the best remaining opportunities to bridge the US 12 fracture zone between Aberdeen and Elma and facilitate broad landscape movements across the Olympics to Cascades South CLOSS in tandem with the I-5 Southern Linkage Zone. One project, the Higgins Slough fish barrier removal project east of Central Park, will

result in a fish and terrestrial wildlife-passable structure in one of these locations. Camera monitoring in the vicinity documented cougar, black bear, black-tailed deer, river otter, and other species directly adjacent to US 12. Those wishing to communicate this location's priority status should refer to the Full Highway System Rankings (Figure 15 and Figure 16).

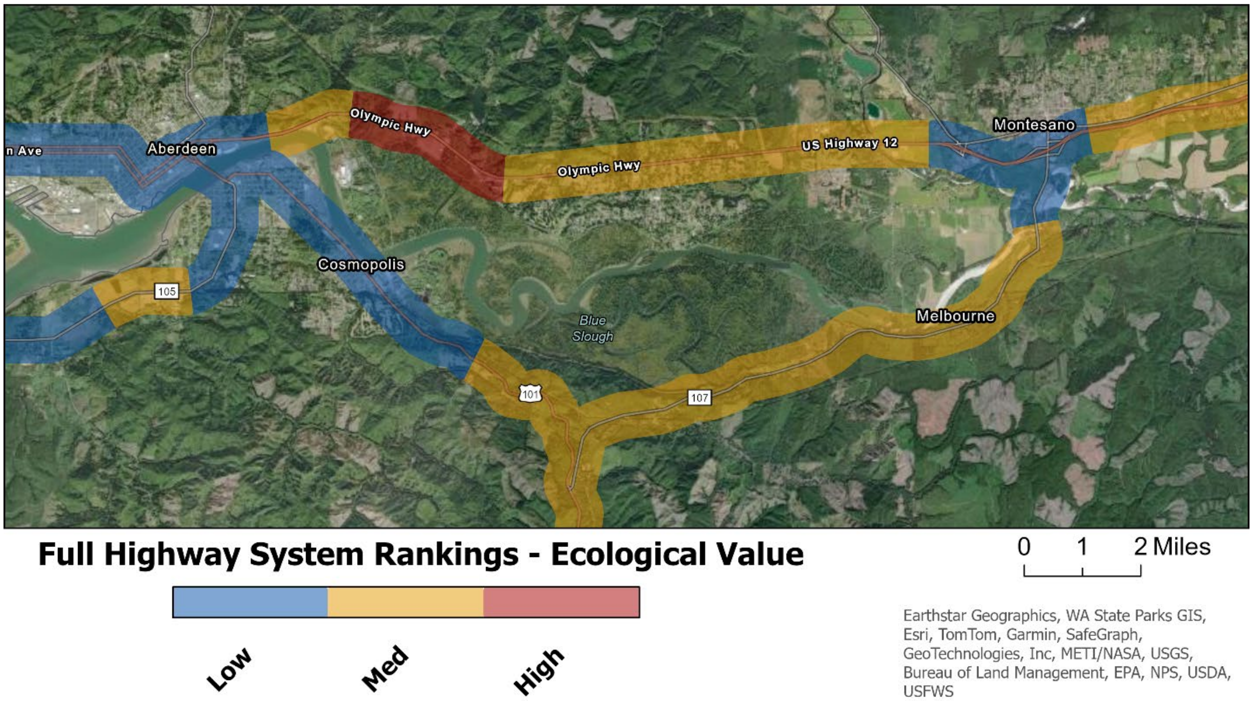

Figure 15. Two one-mile segments west of Central Park ranked high priority within the Ecological Value Full Highway System Rankings.

Figure 16. Three one-mile segments adjacent to and east of Central Park ranked high priority within the Wildlife-related Safety Full Highway System Rankings. High priority status is based primarily on deer-vehicle incidents, though a black bear carcass removal was also documented.

2. **US 12 west of Oakville**. This section of US 12 runs southwest between Elma and Grand Mound, closely following the boundary of Capitol State Forest and has considerably lower traffic (7,964 AADT) than the stretch between Aberdeen and Elma (22,667 AADT). GPS collar data suggests that cougars dispersing/moving into Capitol State Forest after crossing SR 8 often cross US 12 immediately west of Oakville in a narrow corridor (0.25 miles wide) with railroad tracks to reach the Willapa Hills. This crossing location lies between a rock quarry and the town of Oakville (Figure 17). Due to development and lack of forest cover along the Chehalis River, the area was not captured in the Ecosystem Cores and Corridors model – resulting in a lower raw Landscape Connectivity Value score. Nevertheless, documented cougar crossings moving from the Olympic Peninsula to the Willapa Hills by way of Capitol State Forest supports its significance and is identified as regionally important in the Connected Landscapes of Regional Significance (CLORS).

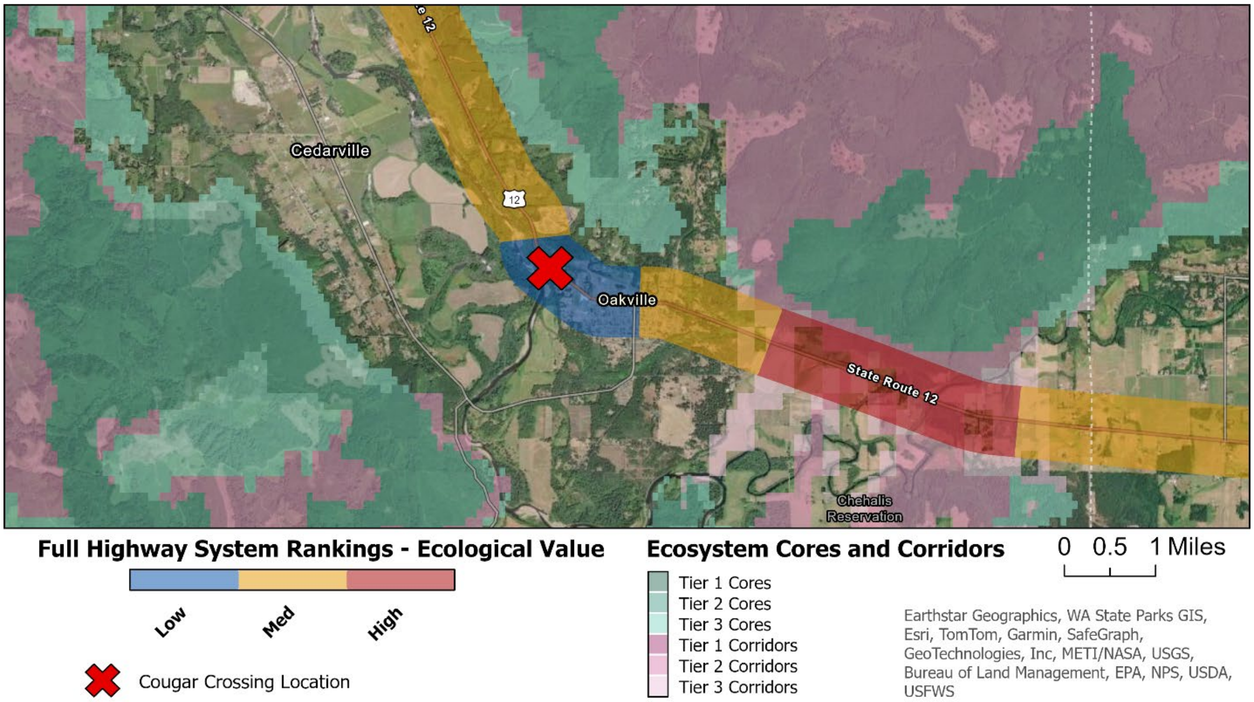

Figure 17. The Ecosystem Cores and Corridors did not intersect the one-mile segment containing the location of interest (red X), resulting in a low Ecological Value rank. US 12 east of Oakville, where this intersection does occur, ranked high priority for Ecological Value. However, GPS-collared cougars were documented crossing US 12 west of Oakville, but not east of Oakville.

Figure 18 shows connectivity priorities and Table 12 summarizes key threats and conservation opportunities in the Southwest Washington and Olympic Peninsula Region.

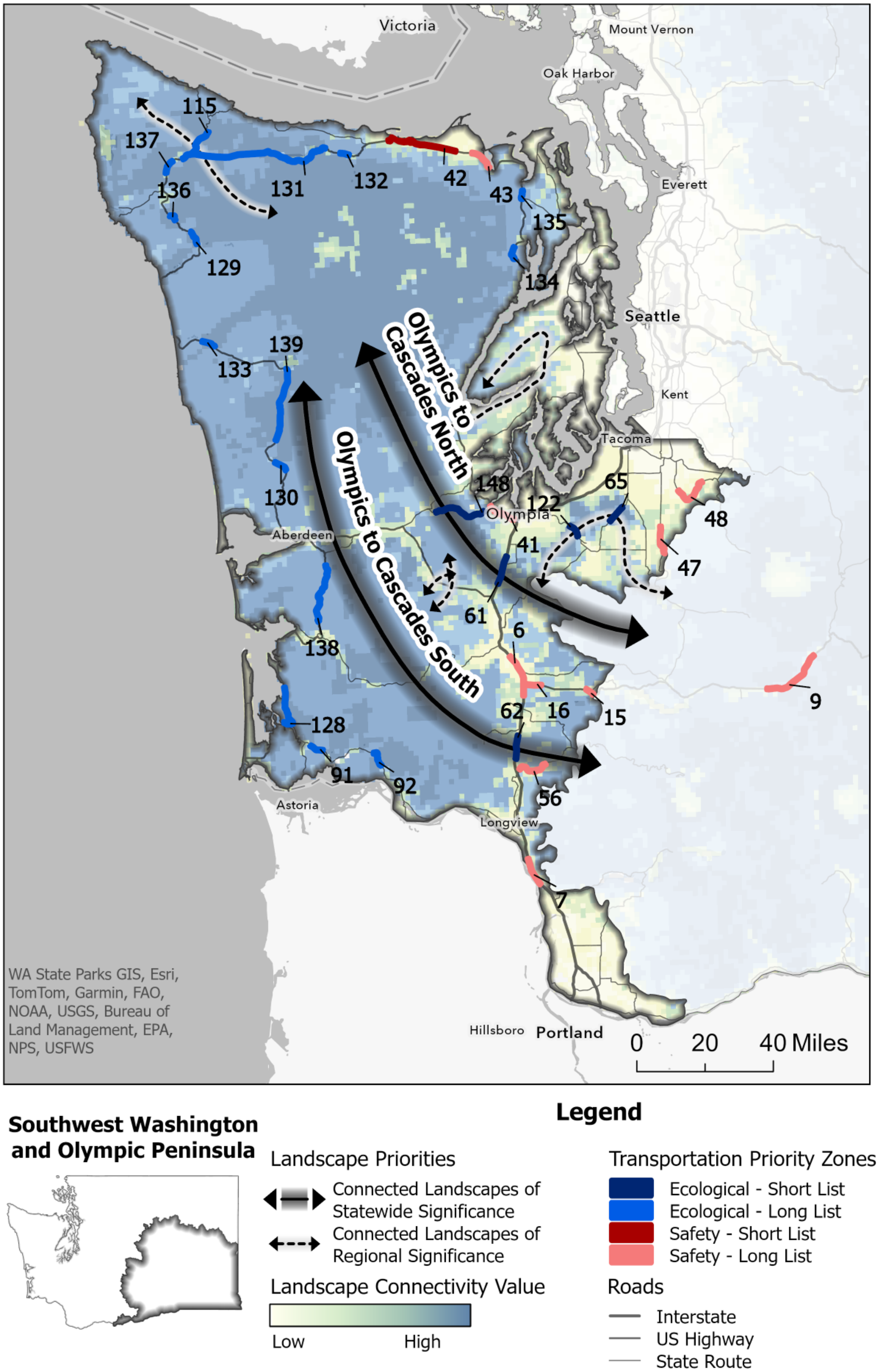

Figure 18. Landscape and transportation connectivity priorities in Southwest Washington and the Olympic Peninsula. Label numbers for transportation priorities are for reference and do not reflect priority.

Table 12. Key threats to ecological connectivity in the Southwest Washington and Olympic Peninsula Region and corresponding conservation and restoration opportunities aimed at maintaining and enhancing habitat connectivity and wildlife movement.

Threat to Connectivity	Conservation & Restoration Opportunity
Transportation Infrastructure: I-5 and US 12/SR 8 severely fragment habitats, substantially restricting wildlife movement across the region. Rapid development, particularly along I-5 and US 12, threatens loss of limited connectivity opportunities.	**Wildlife Crossings:** Implement wildlife crossings and road mitigation strategies along I-5 and US 12/SR 8 to reconnect isolated habitat cores, including Olympic National Park, Cascade foothills, and the Willapa Hills. **Integrate Connectivity into Existing Transportation Projects:** Incorporate terrestrial wildlife connectivity considerations into planned fish passage remediation projects to achieve broader ecological connectivity benefits and reductions in wildlife-vehicle collisions.
Residential and Commercial Development Pressure: Expansion of development along highways and existing urban areas reduces opportunities to protect and restore connectivity.	**Conservation Incentives:** Use voluntary conservation incentives, willing-seller acquisitions and easements to support agricultural and small forest landowners and maintain rural landscapes that provide with wildlife connectivity. **Land use planning**: Consider designating Open Space Corridors and Zoning to protect locally significant cores and corridors threatened by rapid development. **Riparian Corridor Protection:** Protect riparian corridors along river systems to preserve natural connectivity pathways. **Resource Land Protection:** Collaborate with private and public landowners to prevent high-intensity land use conversions and maintain landscape permeability.

Timber Harvesting: Timber harvesting impacts connectivity, despite the permeability offered by a mixed-age forest landscape for species such as elk, cougar, and black bear.	**Sustainable Timber Management:** Apply best management practices for timber harvesting to maintain and enhance connectivity across mixed-age forest landscapes.

Additional Resources

- Cascades to Coast Landscape Collaborative: A collaborative partnership that develops science-based tools and strategies to support a resilient landscape.
- Washington Wildlife Habitat Connectivity Working Group » Cascades to Coast Analysis: A connectivity analysis published in 2024 specific to the Cascades to Coast region.
- WSDOT I-5 Linkage Zones: Overview of the I-5 Northern and Southern Linkage Zones targeted for future wildlife crossings.

Columbia Plateau and Blue Mountains

The Columbia Plateau and Blue Mountains region encompasses expansive landscapes characterized by two distinct ecological zones. The Columbia Plateau is dominated by sagebrush steppe, which has experienced significant declines due to substantial land conversion to agriculture, ranching, residential and commercial developments, and renewable energy projects. The region's remaining shrubsteppe habitat on the Columbia Plateau is highly fragmented, presenting significant challenges to ecological connectivity. This region is home to numerous sagebrush-obligate species, which are similarly imperiled due at least in part to habitat loss and fragmentation. In contrast, the Blue Mountains predominately features dry forest type ecosystems, with substantial portions of public lands managed for multiple uses that include wildlife and other natural resource uses.

Major highways significantly fragment habitat across the Columbia Plateau and Blue Mountains. Several major routes—each with wide-ranging traffic volumes—creates substantial barriers to wildlife movement in this region.

- **US 2** runs east-west in this region from Wenatchee to Spokane, and averages 5,500 AADT, but traffic volumes range broadly from 270 to 35,000 AADT, causing severe localized impacts.
- **US 12** also traverses east-west beginning near Yakima in this region and moving into the Blue Mountains near Waitsburg and Dayton before continuing into Idaho. AADT averages 6,143 AADT in this region but varies between 1,000 to 29,000 AADT.

- **Interstate 82 (I-82)** runs north-south, connecting Ellensburg to Yakima and the Tri-Cities across the Columbia Plateau. It averages 23,890 AADT, with volumes ranging from 5,400 to 51,000 AADT – posing a significant barrier to most wildlife species.
- **I-90**, a major east-west route runs from west of Ellensburg to Spokane in this region, crossing Vantage near the Columbia River and other important habitats near Sprague Lake. In the Columbia Plateau, I-90 averages 19,941 AADT and ranges from 12,000 to 93,000 AADT, creating a significant barrier throughout its length.
- **US 97** and **US 97 Alternate Route** run north-south through the region, connecting Wenatchee to Chelan. These highways average 6,236 and 6,403 AADT, respectively, and bisect bighorn sheep winter range.

Sixteen of the 38 Short List transportation Priority Zones are in the Columbia Plateau and Blue Mountains – the highest of any WAHCAP region. One notable area, I-90 Ryegrass to Vantage, is one of the few locations in the state where Ecological Value and Wildlife-related Priority Zones overlap. The surrounding shrubsteppe supports exceptional reptile diversity, including the desert striped whipsnake—Washington's rarest snake. Colockum elk herd winter range abuts I-90 from the north (Kauffman et al. 2024), which likely creates a barrier to southward elk movements and contributes to significant elk-vehicle collision rates, particularly in the winter. While some structures exist along this corridor, they are currently too small to facilitate elk passage; retrofitting them could offer major additional benefits to reptiles and other low-mobility species.

Two additional I-90 Priority Zones – East and West of Sprague – are critical for facilitating movement across the Upper Crab Creek CLOSS. In this segment, I-90 sees 21,000 AADT, functioning as a complete barrier to most species. The surrounding landscapes include Turnbull National Wildlife Refuge and the Channeled Scablands to the south, which support broad species diversity. The Sprague Lake wolf pack was confirmed in this area in 2022, and one of only eight wolf carcass removals ever reported in Washington occurred on I-90 in the West of Sprague Priority Zone in January 2023. Annual wolf count surveys in December 2023 concluded the Sprague Lake wolf pack was no longer a pack, likely expedited by the loss of this female wolf to a wildlife-vehicle collision.

US 12 Waitsburg to Dayton is consistently ranked among the top three deer-vehicle collision locations statewide, including in the WAHCAP transportation analysis. The Priority Zone overlaps white-tailed deer winter range and sees year-round deer activity. Additional mule deer and white-tailed deer winter range in the Blue Mountain foothills is less than five miles east. High deer concentrations near agricultural crops, and the Touchet River running close to the highway likely contributed to elevated deer-vehicle collision rates in this Priority Zone. Several bridge underpasses conveying the Touchet River or tributaries offer opportunities for retrofits. Adding wildlife exclusion fencing and wildlife benches to these underpasses could facilitate safe crossings of the highway and effectively reduce deer-vehicle collisions.

The Columbia Plateau is a critical habitat for species of conservation concern dependent on shrubsteppe habitat. These include sage and sharp-tailed grouse (*Centrocercus urophasianus* and *Tympanuchus phasianellus columbianus*), sage thrasher (*Oreoscoptes montanus*), sagebrush sparrow (*Artemisiospiza nevadensis*), pygmy rabbit (*Brachylagus idahoensis*), Washington ground squirrel (*Urocitellus washingtoni*), white- and black-tailed jackrabbit (*Lepus townsendii* and *L. californicus*), badger (*Taxidea taxus*), burrowing owl (*Athene cunicularia*), ferruginous hawk (*Buteo regalis*), northern leopard frog (*Lithobates [Rana] pipiens*), tiger salamander (*Ambystoma tigrinum*), sagebrush lizard (Sceloporus graciosus), and desert striped whipsnake (*Coluber [Masticophis] taeniatus taeniatus*). The habitat also supports habitat generalists of cultural importance like elk and mule deer and numerous rare and endemic plant species. The shrubsteppe and adjacent habitat also support local economies and livelihoods, mainly through ranching and agriculture.

The Blue Mountains support a diverse range of species including bighorn sheep, black bear, cougar, elk, wolverine, golden eagle, and Washington's only populations of Rocky Mountain tailed frog (*Ascaphus montanus*).

The Washington Shrubsteppe Restoration and Resilience Initiative (WSRRI) provides a comprehensive overview of key issues affecting shrubsteppe on the Columbia Plateau as well as detailed and extensive conservation strategies for that region. We strongly encourage users to refer to the WSRRI report for a more detailed and comprehensive assessment of these issues. Here, we provide a high-level overview of the most significant connectivity issues within the Columbia Plateau portion of this region. The Columbia Plateau contains a small number of large, intact blocks of sagebrush vegetation and numerous smaller patches of native vegetation, often surrounded by agriculture, grazing lands, or non-native vegetation, all of which can provide some but not all of the ecosystem functions of native sagebrush vegetation. Some corridors of native vegetation remain throughout the region.

Depending on the wildlife species and land management practices, lands used for agriculture and grazing can support wildlife movement and provide important landscape permeability. Figure 19 shows connectivity priorities and Table 13 summarizes key threats and conservation opportunities in the Columbia Plateau and Blue Mountains Region.

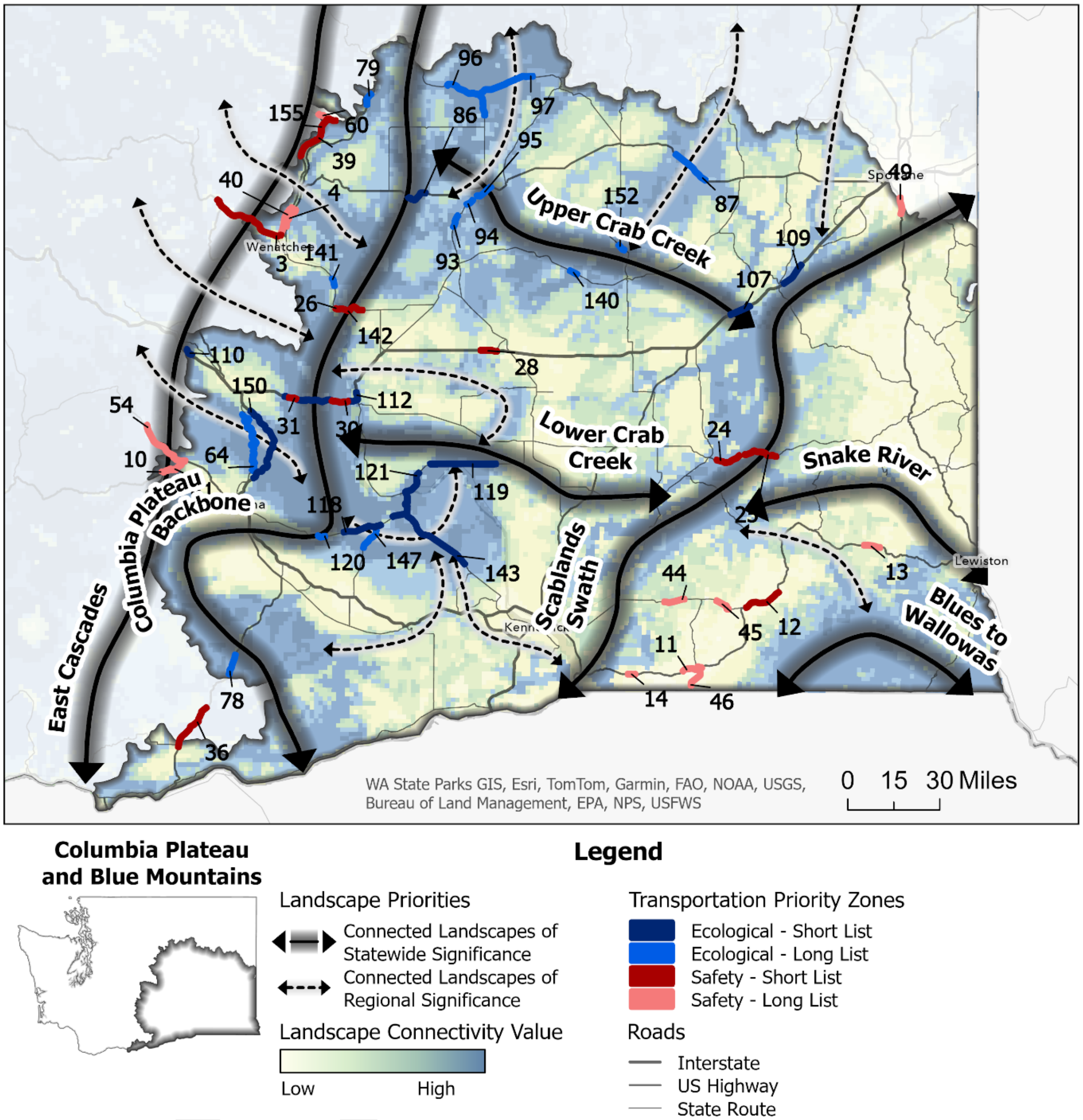

Figure 19. Landscape and transportation connectivity priorities in the Columbia Plateau and Blue Mountains. Label numbers for transportation priorities are for reference and do not reflect priority.

Table 13. Key threats to ecological connectivity in the Columbia Plateau and Blue Mountains Region and corresponding conservation and restoration opportunities aimed at maintaining and enhancing habitat connectivity and wildlife movement.

Threat to Connectivity	Conservation & Restoration Opportunity
Transportation Infrastructure: Major highways, such as I-90, I-82, US 2, US 12,	**Transportation Mitigation:** Establish wildlife crossings and other transportation

US 97 and US 97 Alternate Route create significant linear barriers that restrict wildlife movement, isolate wildlife populations, and increase wildlife-vehicle collision risks.	mitigation strategies along highways to restore landscape connectivity and significantly reduce the risk of wildlife-vehicle collisions. Look for opportunities to retrofit existing structures, including small culverts that could benefit low mobility species and other small animals. Increase research efforts regarding reptile and amphibian use of existing structures in the region.
Habitat Conversion and Fragmentation: Extensive conversion of shrubsteppe habitat to agriculture and residential and commercial development significantly fragments landscapes, diminishing wildlife connectivity.	**Strategic Habitat Protection:** Prioritize the restoration, conservation, and management of remaining large blocks of intact shrubsteppe habitat and existing native vegetation corridors linking these cores. **Corridor Restoration:** Restore degraded habitat cores and corridors to enhance connectivity across fragmented landscapes. **Sustainable Agricultural Practices:** Work collaboratively with agricultural and ranching communities to enhance land management practices that support wildlife permeability and ecological connectivity.
Renewable Energy Development: Large-scale renewable energy installations (e.g., solar, wind) can further reduce and fragment shrubsteppe habitat, impacting connectivity and ecosystem function.	**Renewable Energy Siting:** Integrate wildlife connectivity considerations into renewable energy siting and development to minimize ecological disruptions. **WDFW Wind and Solar Guidelines:** Use WAHCAP spatial data to help evaluate the impacts of proposed solar and wind developments to connectivity structure and function.
Wildlife Impacts: Increasing frequency and severity of wildfires threaten shrubsteppe habitat continuity, especially	**Wildfire Management:** Implement proactive wildfire management and restoration programs aimed at maintaining

in critical corridors linking of shrubsteppe habitat across the region.	connectivity corridors and reducing the impact of wildlife on habitat connectivity.
Irrigation canals: These structures pose a significant threat to the safety of wildlife as animals get trapped into these steep sided canals and are not able to escape on their own. Wildlife as a result either perish or when wildlife professionals are called, often their injuries are so substantial from injuries suffered in the canal that they must be humanely euthanized.	**Wildlife-friendly canal design:** pair wildlife-friendly design features with exclusionary fencing, with the exclusion fencing directing animals to safe crossing locations such as a subsurface piping location or a bridge. These solutions should be incorporated as part of irrigation infrastructure proposals. **Construct retrofits to existing canals:** placing certain sections of the canal into a subsurface piping to provide a safe overcrossing, installing a wildlife friendly bridge over the canal and providing jump outs where trapped animals can safely escape if they become trapped inside of the canal. **Fencing**: Install wildlife exclusion fencing along the canal to direct animals to safe crossing locations.

Additional Resources

- Washington Wildlife Habitat Connectivity Working Group » Columbia Plateau Analysis: A connectivity analysis published in 2010 specific to the Columbia Plateau ecoregion.
- Arid Lands Initiative: A public-private partnership in eastern Washington that coordinates ongoing actions and develops shared priorities to achieve their goals and objectives.
- Washington Shrubsteppe Restoration and Resiliency Initiative: A collaborative, focused effort to conserve and restore wildlife habitats, enhance wildfire preparedness and response, and support working lands in Eastern Washington's shrubsteppe landscape.

Northeast Washington

The Northeast Washington region is characterized by mountainous regions and valleys with sparse urban development, with the exception of Spokane, largely constrained to valley bottoms (e.g., Omak and Colville). The reservations of the Confederated Tribes of the Colville and Spokane Tribe of Indians cover a substantial portion of the landscape, and major portions of the landscape outside these reservations is federally- or state-managed. The Okanogan River Valley extends from the Columbia Plateau ecoregion, creating a natural divide between this region from the Cascade Mountains to the west. Vegetation communities vary significantly across the region, from sagebrush communities native to the valley bottom to forests in the higher elevations. The Okanogan River Valley is heavily influenced by agricultural, residential development, and the north-south US 97, which creates a fracture zone within an otherwise diffusely connected landscape.

Connectivity between Northeast Washington and the Cascades is ecologically important, particularly for shrubsteppe habitats in the Okanogan River Valley, which face fragmentation from land conversion, development, and wildfire. These sagebrush communities have unique ecological importance and are essential for species of conservation concern, including badger, spotted bat (*Euderma maculatum*), burrowing owl, golden eagle (*Aquila chrysaetos*), and sharp-tailed grouse. In the mountainous northeast Washington region, forest management and wildfire regimes create a patchwork of forested lands of varying age classes and structure that support diverse wildlife including black bear, cougar, elk, gray wolf (*Canis lupus*), moose (*Alces alces*), lynx, fisher, wolverine, gray owl (*Strix nebulosa*), and Columbia spotted frog (*Rana luteiventris*).

The US 97 Riverside to North of Tonasket Priority Zone is significant for several reasons. It exhibits the largest overlap between Ecological Value and Wildlife-related Safety Priority Zones statewide and holds the highest Wildlife-related Safety score of any Priority Zone (66.67). This 15-mile stretch of highway consistently ranks among the top three worst deer-vehicle collision locations statewide. Between 2019 and 2023, 421 deer carcasses were removed – averaging nearly six deer carcasses per mile per year. These deer-vehicle collisions primarily involve the Okanogan mule deer herd, one of the state's largest, with occasional collisions involving migratory white-tailed deer.

In addition to deer, the Confederated Tribes of the Colville Reservation are leading an effort to restore pronghorn populations, a species known for long-distance movements and sensitivities to road networks. US 97's traffic volume (5,044 AADT within the Ecological Value Priority Zone) poses connectivity challenges and significant risk of mortality for even high mobility species, such as pronghorn and deer. However, the area's low mobility species, particularly reptiles, are impacted by traffic volume the most. Traffic volumes in this range likely create complete barriers for species like sagebrush lizards, pygmy short-horned lizards, and many snakes, and frequently lead to vehicle-related mortality due to roadside basking, most of which goes unreported. This US 97 Priority Zone is an essential linkage in the Cascades to Rockies CLOSS and forms part of the Columbia Plateau Backbone, making it essential for landscape-scale connectivity.

Two Priority Zones on US 395 (Chewelah to Colville and North of Deer Park) also had significant wildlife-vehicle collision rates. US 395 Chewelah to Colville consistently ranks among the top three deer-vehicle collision locations statewide and recorded the highest total number of deer carcass removals – 590 in total. This Priority Zone also reported collisions involving elk, moose, black bear, and bobcat.

US 395 North of Deer Park Priority Zones shows overlap between Wildlife-related Safety and Ecological Value Priority Zones and serves as an important linkage in the Scabland Swath CLORS. The Priority Zone is notable for its moose presence – recording nine moose carcass removals (the most of any Priority Zone).

US 395 North of Deer Park and US 395 Chewelah to Colville Priority Zones are separated by only six miles, a stretch that also experiences moderate levels of wildlife-vehicle collisions. Together, these three highway segments form a 41-mile span of frequent wildlife-vehicle collisions involving some of the state's largest species, underscoring the need for coordinated mitigation efforts along this entire portion of US 395.

Figure 20 shows connectivity priorities and Table 14 summarizes key threats and conservation opportunities in the Northeast Washington Region.

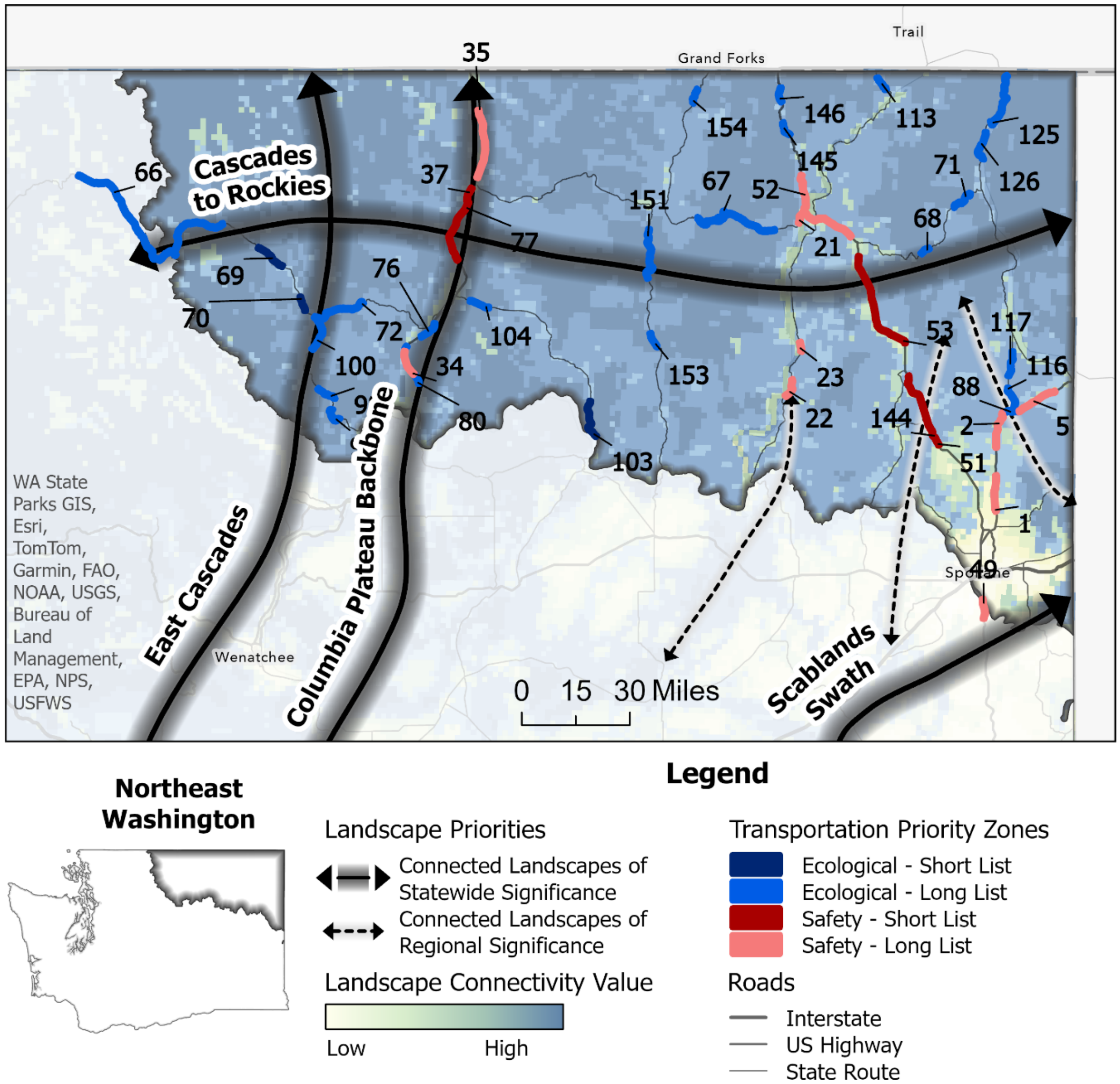

Figure 20. Landscape and transportation connectivity priorities in Northeast Washington. Label numbers for transportation priorities are for reference and do not reflect priority.

Table 14. Key threats to ecological connectivity in the Northeast Washington Region and corresponding conservation and restoration opportunities aimed at maintaining and enhancing habitat connectivity and wildlife movement.

Threat to Connectivity	Conservation & Restoration Opportunity
Transportation Infrastructure: Major highways, such as US 97 and US 395 create significant linear barriers that restrict wildlife movement, isolate wildlife	**Transportation Mitigation:** Establish wildlife crossings and other transportation mitigation strategies along highways to restore landscape connectivity and

populations, and increase wildlife-vehicle collision risks.	significantly reduce the risk of wildlife-vehicle collisions. Look for opportunities to retrofit existing structures, including small culverts that could benefit low mobility species and other small animals. Increase research efforts regarding reptile and amphibian use of existing structures in the region.
Wildfire Impacts: Wildfires temporarily, but significantly, affect habitat structure and connectivity for forest-dependent and shrubsteppe-dependent species.	**Wildfire Management:** Implement pre-dire response planning and preparation and post-fire response and restoration coordination.
Residential and Commercial Development Pressure: Urban and residential expansion within valleys disrupts connectivity between otherwise permeable upland core habitats.	**Strategic Land Use and Protection:** Promote strategic land use planning and land protection measures to maintain ecological connectivity in developing valleys.
Resource Extraction and Recreation Impacts: Activities on public lands, including timber harvest and recreation, can fragment habitats and disrupt connectivity.	**Public Lands Management:** Manage public lands to support connectivity, balancing resource extraction, recreation, and ecological condition.

Additional Resources

- **Washington Wildlife Habitat Connectivity Working Group » Okanagan-Kettle subregion**: A connectivity analysis published in 2016 specific to the Okagagan-Kettle region in northeast Washington.
- The northern extent of the Columbia Plateau ecoregion extends into northeastern Washington. In these areas of primarily shrubsteppe habitat, the resources from the Columbia Plateau and Blue Mountains will also be useful.

Northwest Washington

The Northwest Washington region is primarily located within the Puget Lowland ecoregion, characterized by dense and rapidly expanding urban centers interspersed with extensive agricultural regions. Forest ecosystems in the region are highly fragmented due to development and extensive road networks. Prior connectivity analyses have identified little to no core habitats or functional ecological corridors due to the extensive human impact throughout this region. However, isolated patches of locally significant forest habitat and potential corridors exist, riparian corridors provide natural connectivity, and variability in development densities can create a heterogeneous mix of habitat types that support many wildlife species. Species of conservation concern in this region include golden eagle, marbled murrelet, peregrine falcon (*Falco peregrinus*), purple martin (*Progne subis arboricola*), Oregon spotted frog, western toad (*Anaxyrus boreas*), and northwestern pond turtle (*Actinemys marmorata*).

Several notable transportation Priority Zones have been identified in the Northwest Region.

The I-5 Bellingham Wildlife-related Safety Priority Zone has uncharacteristically high deer-vehicle collision rates for an interstate carrying 67,333 vehicles per day. Particularly confounding is that these deer-vehicle collisions occur within Bellingham city limits, which has a population of almost 100,000 people.

The I-90 Snoqualmie to Snoqualmie Pass *Safety* Priority Zone straddles the regional boundary between Northwest Washington and the Cascades. This Priority Zone records significant wildlife-vehicle collisions near North Bend, including the fourth highest elk-vehicle collision rate statewide, numerous deer-vehicle collisions, and a high number of human injuries due to these accidents. The Safety Priority Zone overlaps the Ecological Value Priority Zone of the same name, which extends east to Snoqualmie Pass and lies predominately in the Cascades Region (described in that section).

This Priority Zone also recorded the most black bear carcass removals of any zone (5) and is home to the state's first two wildlife crossing structures, built in 1975 – one of which was retrofitted in 2024 to encourage elk passage. Additionally, several large bridges over the South Fork of the Snoqualmie River have been documented safely passing elk and other wildlife beneath I-90. Although sections of this Priority Zone were originally fenced during the 1975 construction, much of that fencing is overgrown by dense forests and in a state of disrepair – highlighting the maintenance requirements for this type of infrastructure. Long expanses of wildlife fencing can be challenging and expensive to maintain for DOT Maintenance staff, especially in addition to their many other responsibilities. Efforts to share fence maintenance with other agencies and organizations should be further explored. In this particular region, the Upper Snoqualmie Valley Elk Management Group has established a framework to expand upon, volunteering for over a decade repairing wildlife fencing along I-90 – more of these types of partnerships would ensure fencing investments remain effective. Overall, retrofitting these structures with new barrier fencing in this Wildlife-related Safety Priority Zone would significantly reduce wildlife-vehicle collisions.

WAHCAP identified key chains of habitat cores and corridors that extend from the larger, contiguous habitat cores in the Cascade Mountains into the urban fringe. Notably, the Chuckanut Corridor, which has been previously identified and delineated as a critical habitat connection between National Forest land to the east, down to the Salish Sea coast, is also identified in WAHCAP. This corridor is the last remaining linkage of its kind in northwest Washington. Protecting and enhancing connectivity through this crucial and unique habitat corridor is a high priority. A short, two-mile-long Ecological Value Priority Zone was identified crossing I-5 north of Lake Samish and is key to facilitating wildlife movements throughout the Chuckanut Corridor.

Although additional core areas and linkages are identified in this region, limitations of the statewide-scale analysis precluded detailed representation of finer-scale connectivity features throughout this region. As a result, a key next step is to identify important habitat hubs, steppingstones, and corridors to provide connectivity between larger intact habitat areas to the east and the Salish Sea coast to the west. WAHCAP habitat suitability, human footprint, and landscape permeability data produced by TerrAdapt can help identify these areas, especially steppingstones of remaining native vegetation.

Figure 21 shows connectivity priorities and Table 15 summarizes key threats and conservation opportunities in the Northwest Washington Region.

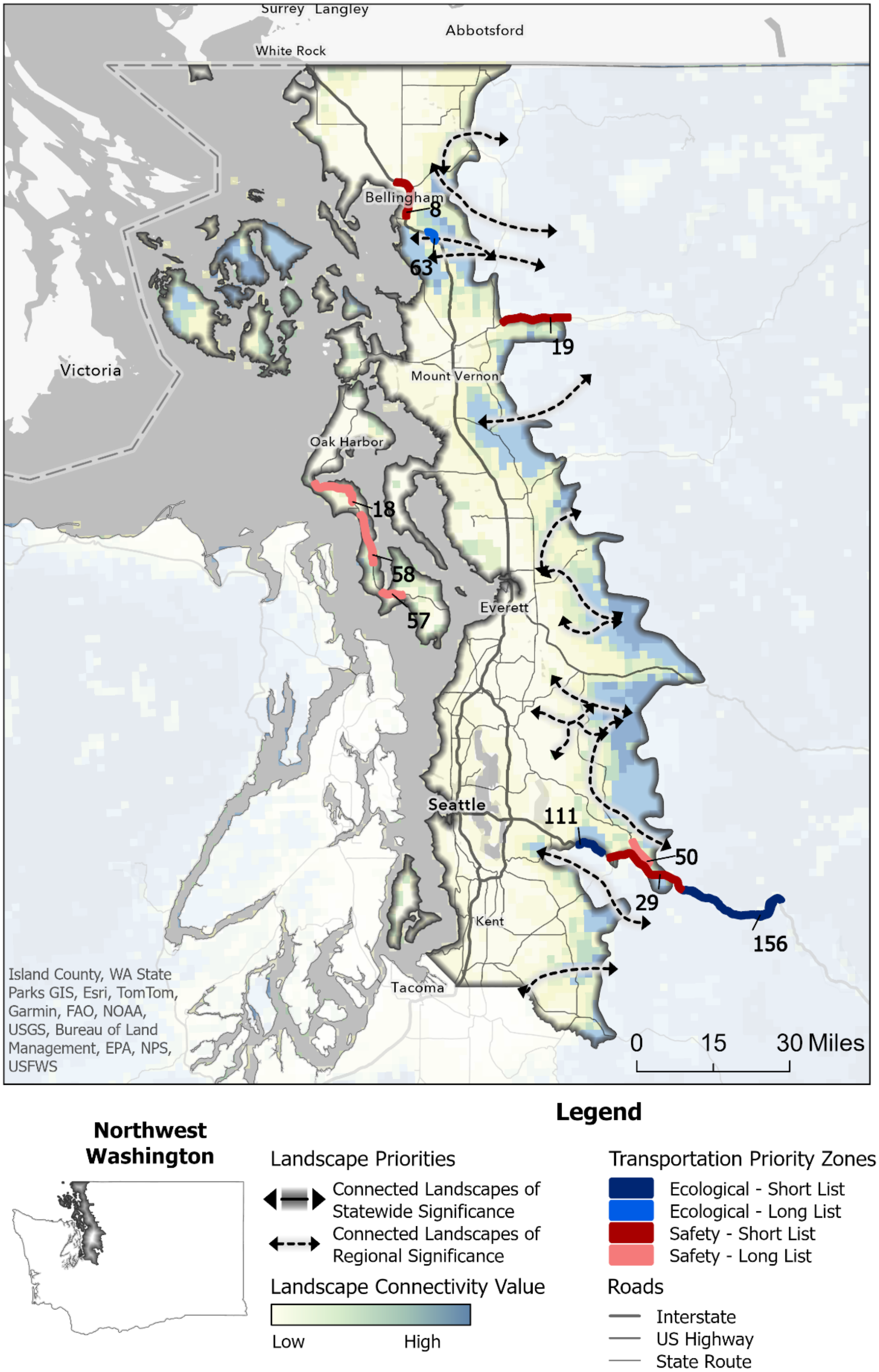

Figure 21. Landscape and transportation connectivity priorities in Northwest Washington. Label numbers for transportation priorities are for reference and do not reflect priority.

Table 15. Key threats to ecological connectivity in the Northwest Washington Region and corresponding conservation and restoration opportunities aimed at maintaining and enhancing habitat connectivity and wildlife movement.

Threat to Connectivity	Conservation & Restoration Opportunity
Urban Development: Expansion of cities such as Bellingham, Everett, along with smaller suburban communities, like North Bend, leads to ongoing loss of remnant forest and landscape connectivity.	**Land-use Planning:** Within urban growth areas, protect and manage riparian and wetland areas to contribute to connectivity. **Core Area Protection:** Outside urban growth boundaries, prioritize conservation of core forest habitats through easements and voluntary conservation incentive programs. For example, focus on areas near the Chuckanut Mountains, around Mount Vernon, and along key connectivity corridors in rural parts of King, Skagit, and Whatcom counties.
Transportation Infrastructure: Fragmentation from major highways (I-5 and I-90) significantly restricts wildlife movement and increases the risk of wildlife-vehicle collisions.	**Wildlife Crossings:** Implement wildlife crossings and road mitigation measures along highways to restore connectivity between habitat cores and reduce wildlife-vehicle collisions.
Recreation Pressure: Recreation, particularly in areas like Mount Baker-Snoqualmie National Forest, degrade habitat quality and fragment habitat.	**Manage Recreation:** Work with public land managers to balance recreational access with minimizing ecological disturbances.

Additional Resources

- **Wildlife Habitat Connectivity in Whatcom County, Washington**: An analysis published in 2023 to identify critical connectivity areas in Whatcom County.
- **Wildlife Corridor Analysis - City of Bellingham**: An analysis published in 2021 to identify important areas for habitat connectivity in Bellingham, Washington.

Future Directions and Recommendations

The WAHCAP identifies clear, science-based priorities for restoring and enhancing habitat connectivity across the state. With these priorities now established, the critical next step is active implementation—translating strategic connectivity recommendations into tangible actions on the ground.

WSDOT and WDFW, as state government agencies, have central roles in guiding and facilitating these efforts. Their responsibilities include embedding WAHCAP's ecological and safety priorities into routine state government planning processes, infrastructure project development, and policy decisions. However, achieving meaningful and lasting connectivity improvements requires collaboration and leadership beyond state agencies. Local governments, tribes, conservation organizations, private landowners, and community stakeholders will all play essential roles in successful implementation.

Mainstreaming landscape connectivity into existing plans, policies, and procedures is essential for ensuring effective implementation. For example, planning counties should incorporate habitat connectivity explicitly within their Growth Management Act (GMA) comprehensive plans, critical areas ordinances, and zoning regulations. State agencies—particularly WDFW—have a distinct role in providing clear direction, technical support, and guidance to local jurisdictions, enabling them to effectively embed connectivity principles into their local planning and regulatory frameworks. By systematically incorporating connectivity into existing processes, habitat connectivity can become a fundamental element of routine decision-making across jurisdictions.

Policy integration across state agencies, government levels, and sectors also provides significant opportunities to increase connectivity. Aligning habitat connectivity with existing initiatives and processes, such as climate resilience planning, transportation safety programs, local comprehensive planning, transportation planning, and land-use regulation updates, ensures that connectivity objectives are comprehensively addressed and coordinated across decision-making processes.

Implementation also involves addressing emerging threats to connectivity, such as climate change, land conversion, and increased recreational pressure on public lands. Initiatives like the State-Tribal Recreation Impact Initiative (STRII) provide models for collecting and integrating improved recreation data into public land management decisions. Additionally, new tools like the Department of Commerce's zoning atlas can provide critical insights into development risks, helping inform strategies to mitigate habitat fragmentation resulting from future land-use changes.

Ultimately, WAHCAP provides a shared vision for an ecologically connected Washington, where wildlife move safely across the landscape, ecosystems remain permeable, and risks from wildlife-vehicles collisions are significantly reduced. Successful implementation depends on proactive partnerships, effective stakeholder outreach, securing dedicated funding, and ongoing collaboration across multiple sectors. Collectively, these efforts will deliver lasting ecological benefits and enhance community safety and resilience throughout Washington.

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Appendix A. Acronyms and Glossary of Key Terms

Acronym	**Definition**
AADT	Average Annual Daily Traffic
ACEP	Agricultural Conservation Easement Program
ALI	Arid Lands Initiative
ARM	Accumulated Route Mileage
ATNI	Affiliated Tribes of Northwest Indians
BAC	Biodiversity Areas and Corridors
BLM	Bureau of Land Management
CAO	Critical Area Ordinance
CLORS	Connected Landscapes of Regional Significance
CLOSS	Connected Landscapes of Statewide Significance
CNW	Conservation Northwest
CPP	Countywide Planning Processes
CSP	Conservation Stewardship Program
EQUIP	Environmental Quality Incentives Program
GMA	Growth Management Act
HCP	Habitat Conservation Plan
HATS	Highway Activity Tracking System
IAG	Implementation Advisory Group
ISA	Incremental Spatial Autocorrelation
NGOs	Non-government organizations
PHS	Priority Habitats and Species
NPS	U.S. National Park Service
NRCS	Natural Resource Conservation Service

OHSA	Optimized Hot Spot Analysis from ArcGIS spatial tools
SGCN	Species of Greatest Conservation Need
STRII	State-Tribal Recreational Impacts Initiative
SWAP	State Wildlife Action Plan
TAG	Technical Advisory Group
UGA	Urban Growth Areas
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
WAHCAP	Washington Habitat Connectivity Action Plan
WCRD	Wildlife Carcass Removal Database
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington Department of Natural Resources
WSDOT	Washington State Department of Transportation
WSRRI	Washington Shrubsteppe Restoration and Resilience Initiative
WHCWG	Washington Wildlife Habitat Connectivity Working Group

Key Term	**Definition**
Accumulated Route Milage (ARM)	The measure of a point along the length of a state route in which the distance is measured as an accrual of mileage from the beginning of the state route.
Barrier Effect	The inability of wildlife to cross linear infrastructure like roads due to physical limitations, behavioral responses to noise, light and other disturbances, and/or mortality suffered from wildlife-vehicle collisions. Traffic volume (AADT) is often used as a surrogate for measuring the barrier effect of roads.
Connected Landscape of Statewide Significance (CLOSS)	A broadly identified collection of core areas and corridors that collectively create a connected network of ecologically significant lands across the primary ecosystems of Washington State
Connected Landscape of Regional	A broadly identified collection of core areas and corridors that collectively create a connected network of ecologically significant lands across regions within Washington State.

Key Term	Definition
Significance (CLORS)	
Core	Conceptually, core areas are the places that a connectivity network seeks to connect. Cores are blocks of habitat large enough to support at least several home ranges for multiple individuals or species. These areas must have sufficient habitat quality and be of a sufficiently large size to support wildlife populations and their essential life history functions. In connectivity modeling, cores are defined as relatively large, intact, high-quality blocks of habitat or target vegetation (Forman 1995). Areas within cores have a low human footprint and are internally well connected.
Corridor	Corridors are the pathways or linkages between habitat cores. For most large and highly mobile species, corridors provide habitat sufficient to facilitate movement but are not identified to sustain permanent populations. Species with limited mobility may need to reside within corridors and only achieve migration over multiple generations. In core-corridor modeling, corridors differ from cores because their habitat quality is lower or too linear to function as core habitat (Bennett et al. 2003, Hilty et al. 2012).
Fracture zone	A relatively narrow band of low ecological permeability that inhibits movement between otherwise ecologically well-connected landscapes. Fracture zones are often caused by roads and associated residential and commercial development that occurs along roads.
Habitat Connectivity	The degree to which the landscape facilitates or impedes animal movement and other ecological processes
Habitat Connectivity - diffuse	Widespread connectivity with few barriers to impede or constrain movement. No single identified pathway exists through these landscapes and thus wildlife can move freely without specific routes in the landscape.
Habitat Connectivity - concentrated	Moderate habitat loss constrains or narrows movement options, forming wide but constrained corridors.
Habitat Connectivity - channelized	High habitat conversion and modification results in a single remaining route through a heavily modified landscape.
Habitat Connectivity - impeded	Wildlife movement is completely blocked or precluded, such as by high-traffic roads or a clearcut for species that require forest canopy.
Habitat Suitability	Habitat suitability in general refers to how well habitat conditions and characteristics match the habitat needs of a species. Locations with

Key Term	Definition
	high habitat suitability for a species provide the habitat characteristics that species needs. In the context of this report, TerrAdapt created "Habitat Suitability" data for each of the ecosystems modeled in this analysis. In this case, "Habitat Suitability" refers to how well the location matched the climatic and physical vegetation characteristics of the targeted ecosystem and the level of human footprint modification in that ecosystem, with higher human footprint modification equating to lower "Habitat Suitability."
High Mobility Species	Species with the ability to move long distances and across large regions. Examples include large ungulates and carnivores, species with large-scale migrations, and many birds.
Landscape Connectivity	Habitat connectivity across the broader landscape, not limited to transportation networks. Strategies to enhance landscape connectivity include land use planning, voluntary conservation incentives, and habitat protection, management, and restoration.
Landscape connector	A discrete landscape unit that connects ecological elements within a connected landscape.
Low Mobility Species	Small, slow-moving species that require specific ambient conditions such as moisture and light. Frogs, toads, salamanders, some small mammals, and ground insects are examples. Need species-specific habitat consistent with external conditions (light, moisture) throughout the entire structure, and are inordinately sensitive to traffic volume, including low levels of AADT.
Priority Areas (in relation to transportation)	Any one-mile segment ranked high within the Full Highway System Rankings, or any transportation Priority Zone (Long or Short List)
Transportation Connectivity	The ability of wildlife to safely cross roads, which is typically addressed with infrastructure like wildlife crossings and fencing. There are two primary goals, improving wildlife movement and improving public safety by reducing wildlife-vehicle collisions.

Appendix B. Transportation Connectivity Priority Zones

This link provides a downloadable table with detailed attribute data for each of the WAHCAP Transportation Priority Zones: **WAHCAP Transportation Priority Zones Table**.

This link provides a downloadable table that lists both WDFW Priority Species and Washington Species of Greatest Conservation Need associated with each Ecological Value Priority Zone. Associations are based on spatial data compiled from WDFW's Priority Habitats and Species (PHS), Species of Greatest Conservation Need (SGCN) from the 2015 State Wildlife Action Plan, and Wildlife Occurrence data for species. This list of species provides a flagging tool for identifying species which ***might*** be present near the Ecological Value Priority Zone but does not replace field surveys to verify which species are or are not present. Species listed in this table might not actually be present on site and species which are not listed might be present on site: WAHCAP Ecological Priority Zone Species Table.

GIS data layers identifying the high priority one-mile segments of the Full Highway System Rankings for Ecological Value and Wildlife-related Safety are available through this ArcGIS Online link, which also provides spatial data from the WAHCAP including:

- Landscape and transportation priority locations.
- Landscape connectivity value input data at a finer resolution than the WAHCAP analysis.
- Key additional administrative layers like protected areas and roads.

The data can be viewed in a webmap or opened in desktop ArcGIS applications. Data will be available for download once the final WAHCAP is published. Additional instructions for accessing the data are available on the linked AGOL landing page.

Appendix C. Landscape connectivity values data layer descriptions

Ecosystem Connectivity (Input layer 1)

Purpose: The ecosystem connectivity layer provides a current evaluation of structural connectivity for four major ecosystem types representing the majority of habitat in Washington State. These models are intended to provide a "coarse-filter" or habitat-based approach to modeling habitat connectivity. Habitat-based connectivity models are intended to represent connected habitat for many, although not all species that use that habitat type. This is particularly important for species which cannot be modeled directly due to a lack of data or insufficient knowledge of their connectivity needs.

Data description: We contracted with TerrAdapt to map ecosystem cores and corridors for all of Washington as well as parts of neighboring states and provinces (Oregon, Idaho, Montana, and British Columbia) (see Appendix E for details). This provided a buffer beyond the state border and facilitated a transboundary understanding of patterns of habitat and connectivity. Within this extent, we identified and mapped 4 ecosystems including:

1. Temperate forests distributed along the lower elevation coastal areas of western Washington, Oregon, and British Columbia.
2. Montane mesic forests distributed across the higher elevations of the Olympic and western Cascade Range in Washington as well as the western Coast Range in British Columbia, and the higher elevations of the Rockies, Kettle Range, Selkirks, Blue Mountains, and Wallowas.
3. Montane xeric forests distributed across the eastern side of the Cascade Range in Washington as well as the eastern side of the Coast Range in British Columbia and much of the lower to mid-elevation forests in the Rockies, Kettle Range, Selkirks, Blue Mountains, and Wallowas.
4. Shrubsteppe habitat distributed across the Columbia Plateau in Washington and extending up the Okanogan Valley into British Columbia.

We based habitat and connectivity for each ecosystem on ecosystem-specific preferences for climate and vegetation as well as avoidance of areas with human modification, referred to here as "human footprint."

Human footprint data

TerrAdapt's human footprint model was used across the ecosystem models to quantify the impact of human activities on habitat and connectivity. These models reflected the cumulative effects of a variety of stressors, including the impacts of the transportation and energy infrastructure (e.g., state, local, and forest service roads, transmission lines, wind turbines, solar farms, pipelines, and surface mines), agriculture, forestry, urbanization, and recreation (e.g., ski areas, campgrounds, and trails). These impacts were represented in the models as site-level impacts (e.g., the impact of the paved road) as well as distance effects that radiated out from the site. The distance and magnitude of those effects were scaled to account for the types of human activities, noise and light, invasive species, pollution, and other area effects that tend to coincide with the impacts at the site.

TerrAdapt's human footprint model was also used to create a generic wildlife movement "resistance" model reflecting the impacts of the human footprint on hypothetical wildlife movement. This model reflects the fact that some human activities may result in poor habitat quality, but still provide some measure of permeability to movement (e.g., an irrigated agriculture field may not be habitat to many species, but many species have at least some capacity to move across fields as they disperse between habitat patches).

TerrAdapt's human footprint data was created analyzing a time series of satellite imagery from 1984-2022. Analyzing this time series allowed us to account for ephemeral disturbances (e.g. wildfires removing forest, followed by regeneration) differently from permanent anthropogenic disturbances like urbanization and conversion to agriculture.

Mapping ecosystem cores and corridors

For each of the four ecosystems, TerrAdapt mapped habitat cores and then corridors between cores. Habitat cores are large, intact blocks of high-quality, internally well-connected habitat (i.e., resistance to movement inside the core is low and there are no major movement barriers). Corridors were mapped using the least cost corridor method.

Habitat quality was defined by the climatic conditions, vegetation characteristics, and level of human footprint (or resistance). For example, for the temperate forest ecosystem, high-quality habitat areas have a temperate climate, are predominantly forest vegetation, and lack high degrees of urbanization, agriculture, and infrastructure. For the shrubsteppe ecosystem, high-quality habitat includes locations with an arid climate, predominantly shrubsteppe vegetation, and minimal urbanization, agriculture, and infrastructure.

Ecosystem Core and Corridor Tiers

Within each ecosystem, we mapped 3 different 'tiers' of habitat cores and corridors reflecting a range of sensitivities to suboptimal climate, vegetation, and exposure to the human footprint (Figure 22). The Tier 1 models represented specialists within the ecosystem that are highly sensitive to suboptimal conditions. The Tier 3 models represented more generalist species within the ecosystem that have far greater tolerance for suboptimal climate, thrive in a more diverse mosaic of vegetation types, and have greater tolerance of human modified landscapes. The Tier 2 models represented an intermediate degree of tolerance. Together, the 3 tiers allow for a diverse suite of selection behaviors to be represented and facilitates comparison of areas that are only likely to be used by specialists versus areas on the urban fringe that may be compatible with species that have higher tolerances.

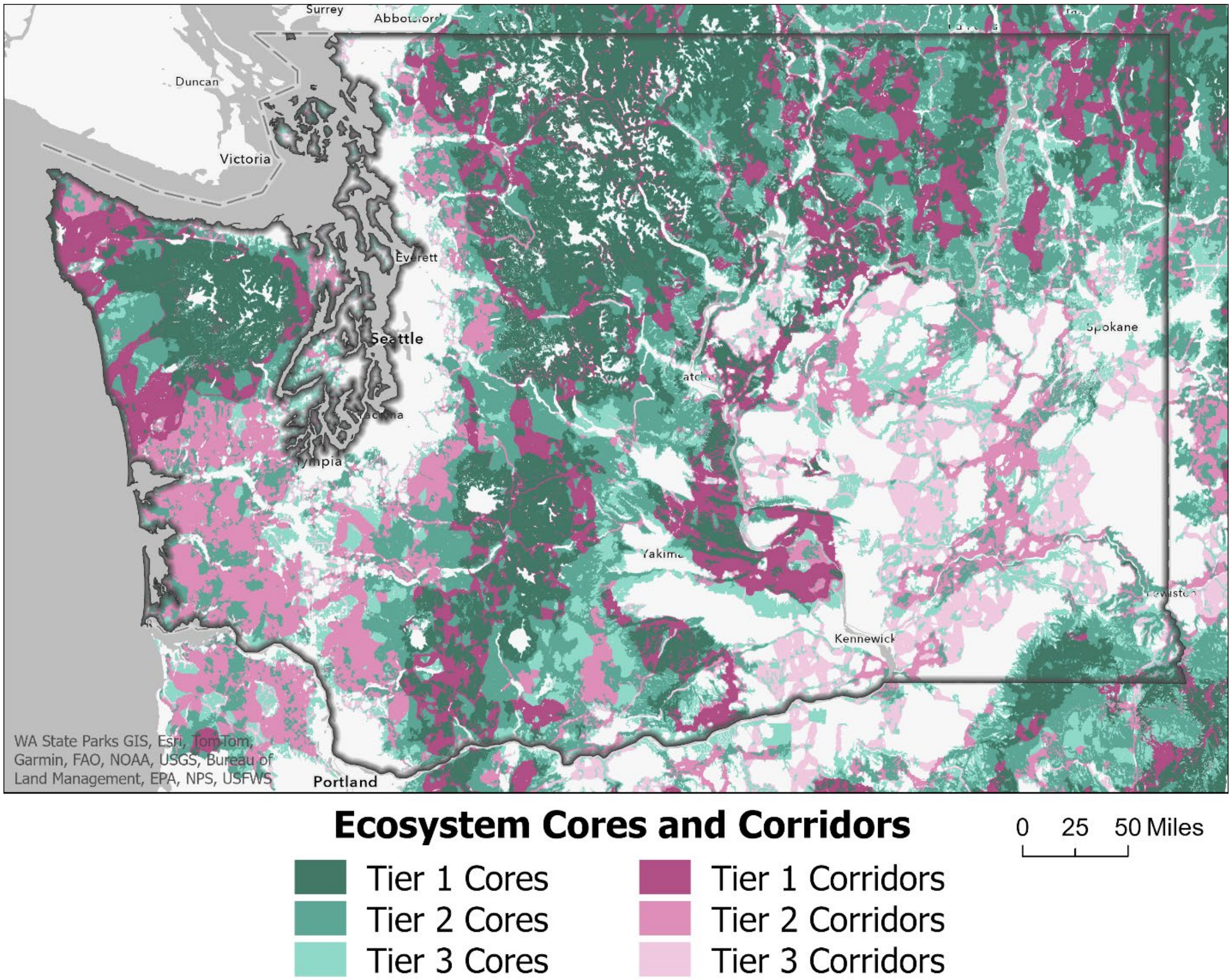

Figure 22. Tiered Ecosystem Cores and Corridors map.

We created a single Ecosystem Connectivity input data layer by combining the three tiers for each of the four ecosystems (12 total layers). We used the following prioritization schema: Tier 1 core > Tier 1 corridors > Tier 2 cores > Tier 2 corridors > Tier 3 cores > Tier 3 corridors. Where multiple ecosystems overlapped, we assigned each location the highest Tier score among all overlapping ecosystem features.

As a final step, we ran a 20-mile radius moving window analysis to adjust the final score values based on the range of scores within that moving window (Figure 23). This was done to elevate locations that were the highest scoring within that moving window region.

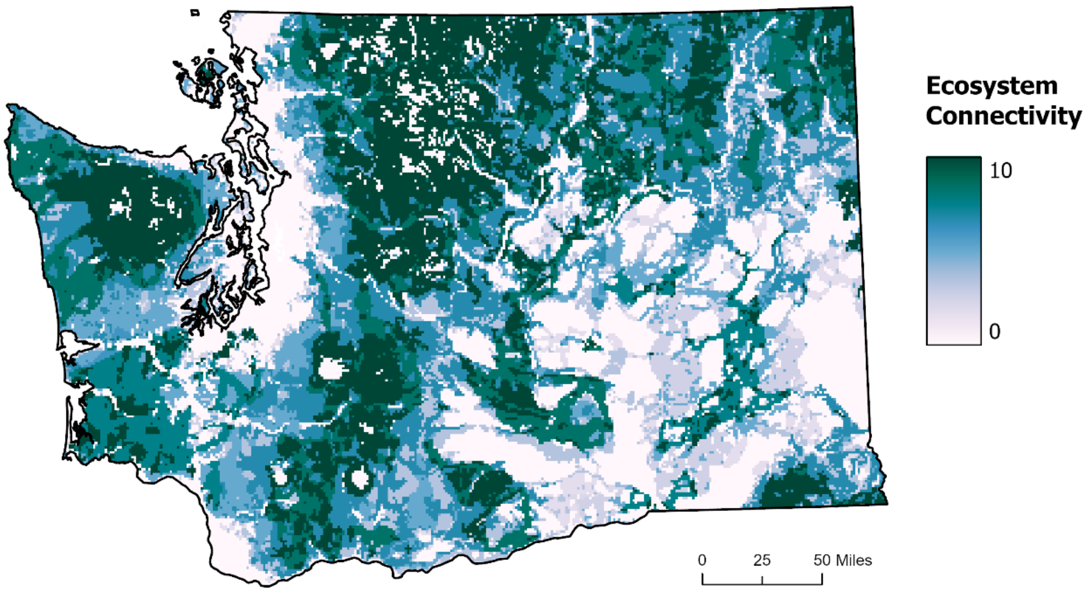

Figure 23. Final Ecosystem Connectivity input layer.

Westside Prairie Ecosystem (Input layer 2)

Purpose: Westside prairie vegetation is a WDFW Priority habitat (WDFW 2008). This habitat type is restricted in extent to the South Puget Sound region of Washington. Developing a targeted connectivity analysis for this habitat type was outside the scope of this project. However, the forest-based ecosystem models did not capture this important habitat type, leaving a significant gap in our prioritization.

Data description: We developed a data layer to represent potential Westside Prairie habitat based on the presence of prairie soils, the absence of human footprint disturbance, and absence of trees (Figure 24).

Based on stakeholder review comments, we included westside prairie as a fifth ecosystem type in addition to temperate forest, montane mesic (wet) forest, montane xeric (dry) forest, and shrubsteppe.

Figure 24. Westside Prairies input layer.

Permeability (Input layer 3)

Purpose: The least-cost corridor models represent the most efficient routes between core areas given the resistance in the landscape. However, the distribution of corridors is highly sensitive to the location of the core areas, and habitat outside of cores is not represented as a source for movement in core-corridor models. As a complementary alternative method to map connectivity that does not depend on first mapping core areas, we used permeability models (Gallo et al. 2019).

Data description: This method assesses the degree to which each location on the landscape is connected to its neighbors. The result represents the local permeability of the landscape as a continuum without defining core areas or corridors (Figure 25).

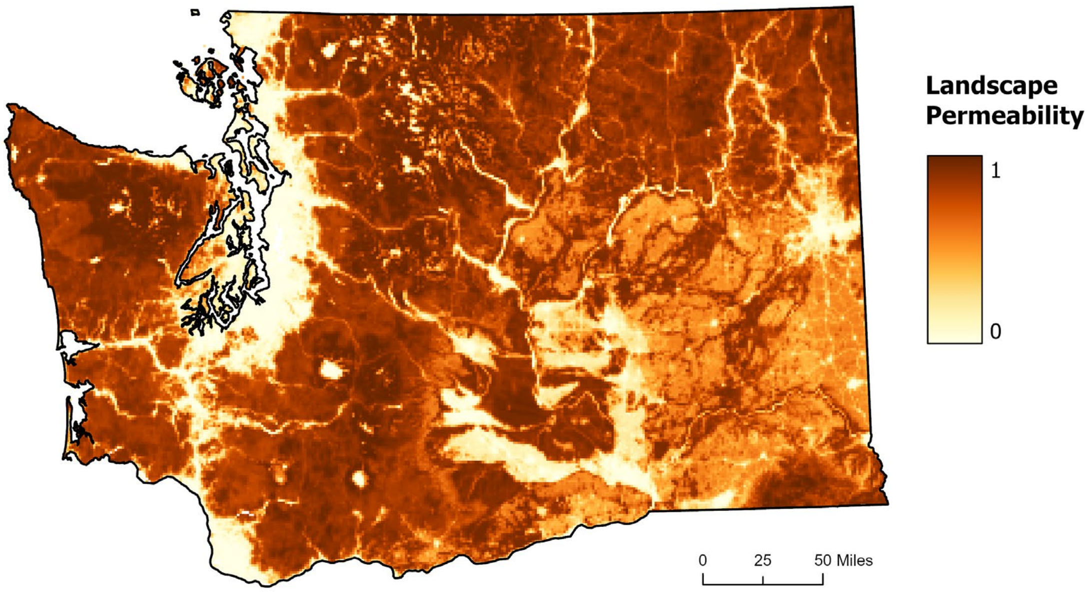

Figure 25. Permeability input layer.

Network importance (Input layer 4)

Purpose: One shortcoming of the core-corridor and permeability models is that they reveal the best routes through a landscape (between core areas, and locally to neighboring pixels, respectively), but they do not reflect the importance of the routes to the overall statewide network. Routes connecting two large core areas containing substantial high-quality habitat are much more likely to be used by dispersing individuals compared to routes that connect smaller and/or lower quality cores. This metric captures that relative importance *at the statewide scale*.

Data description: The network importance metric evaluates the importance of different regions based on the patterns of habitat cores and the level of resistance in the landscape (Figure 26). Network importance is measured based on a combination of the size of the habitat core area, the quality of the habitat (i.e., lack of human footprint), and the position of the core in the network. Large cores that are centrally connected to many other cores have a higher network important than smaller cores on the fringe of the network. An understanding of relative dispersal density enables prioritization of the most central parts of the network connecting the most high-quality habitat.

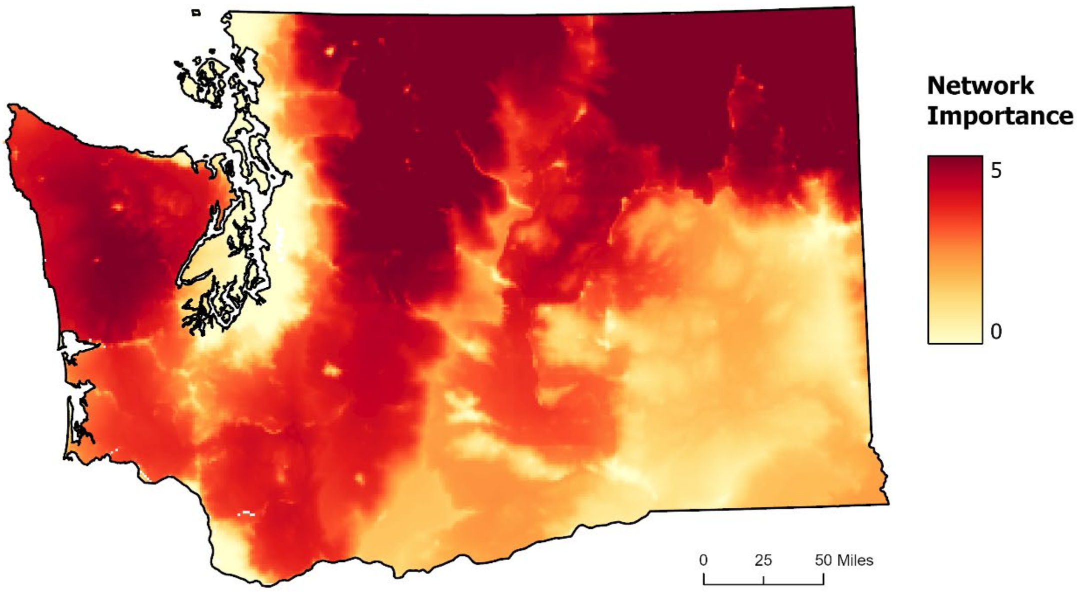

Figure 26. Network Importance input layer.

Focal Species (Input layers 5 and 6)

Purpose: Ecosystem or habitat-based connectivity models are designed to capture a broad suite of species using the ecosystem or habitat being modeled. However, individual species have different preferences for habitat conditions and especially can be tolerant of moving through very different types of landscape features. In connectivity analyses, focal species are selected and modeled individually to help represent a variety of habitat preferences and movement capacities.

Data description: We contracted with Conservation Biology Institute and worked with our TAG to identify existing focal species models to include in this analysis. We then worked with species experts at WDFW and within the TAG to review and evaluate each model. We worked with the experts to update models when possible and appropriate. The experts provided a final recommendation on whether or not to include the model.

We ultimately identified 22 focal species for which adequate spatial information on connectivity (population cores and/or movement corridors) was available (Appendix F: Focal species connectivity model summary table). Based on this review and an assessment of the models, we assigned weights to each species reflecting the species' expert's confidence in model performance and comparison of the modeled habitat location with documented species locations. We then combined the focal species models so that locations supporting more species received a higher score (weighted by confidence of the modeled results) than locations supporting fewer species. Finally, we ran a moving window analysis to rescale the data to account for regional differences in the numbers of focal species modeled in each region (Figure 27).

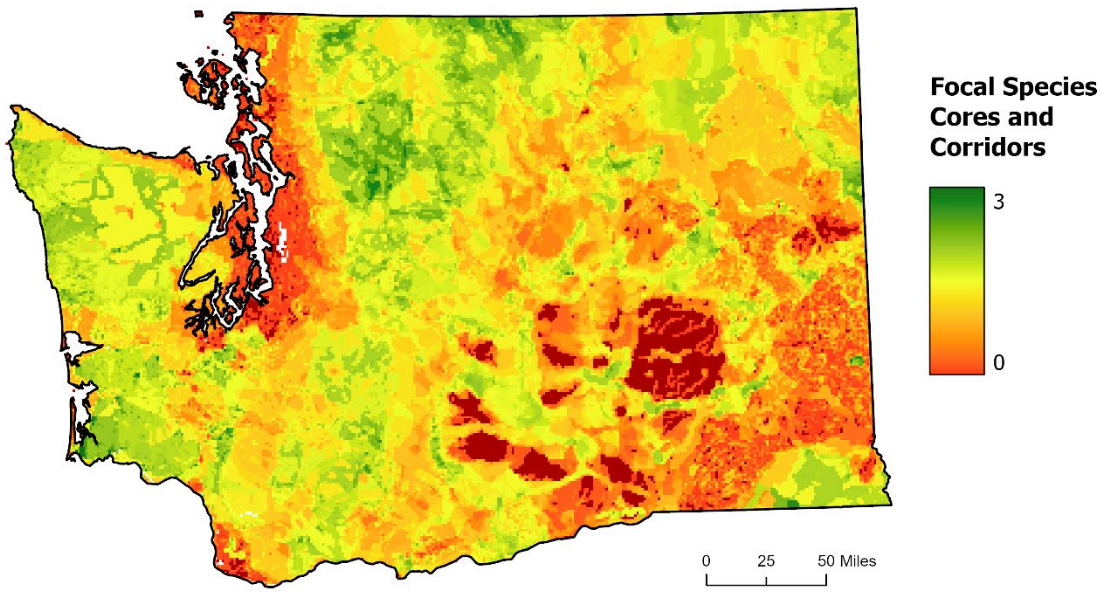

Figure 27. Focal Species input layer, including focal species cores and corridors and the Beaver Intrinsic Potential model.

American beaver (Input layer 6)

Purpose: American beaver (*Castor canadensis*) was repeatedly identified by stakeholders as important species to include in the analysis.

Data description: Two regional American beaver core and connectivity models were available. However, expert reviewers expressed concerns that a) the methods used in each model were different, b) the models were not always representing beaver habitat well, and c) some important regions for beaver were absent, simply because the models had a regional extent.

Instead of using the regional models, we employed the Beaver Intrinsic Potential (BIP) layer (Dittbrenner et al., 2018). The model aims to predict where beaver populations could establish based on hydrologic conditions and the presence of appropriate vegetation. This data layer does not represent *connectivity* for beaver *per se*, but rather identifies locations with high concentrations of potentially good beaver habitat (Figure 28).

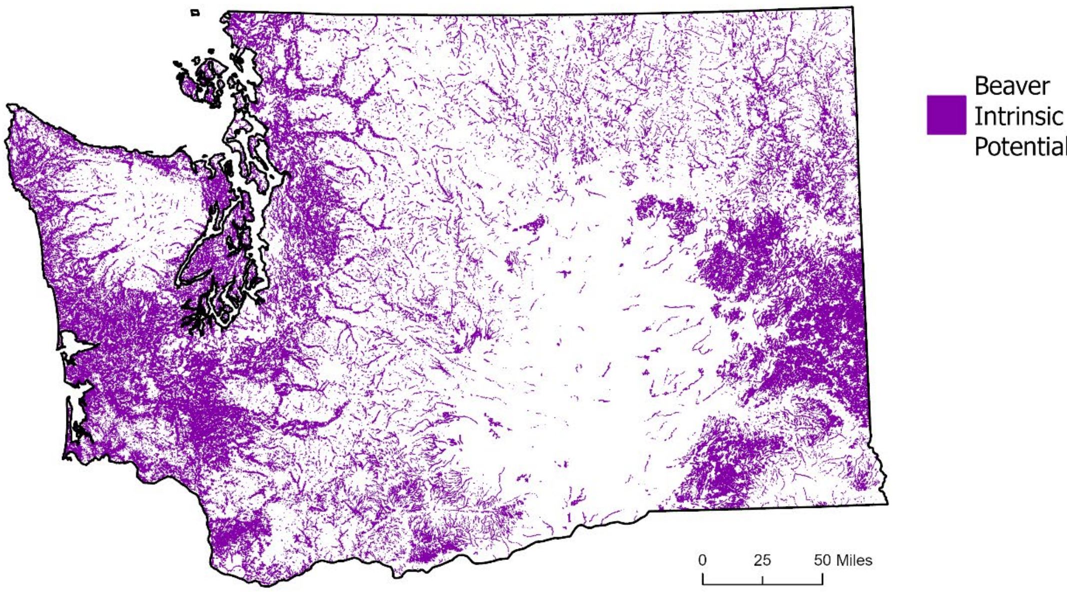

Figure 28. Beaver Intrinsic Potential model. This layer was integrated into the focal species layer (see above).

Species of Greatest Conservation Need (Input layer 7)

Purpose: Species of Greatest Conservation Need (SGCN) are identified in the State Wildlife Action Plan as high priorities for conservation action either because they are currently listed as threatened or endangered or because their populations are declining so that they are likely to become listed without conservation intervention. Locations that support SGCN are important to target for conservation. In addition, many SGCN are smaller and less mobile species including amphibians and reptiles. Modeling connectivity for these species remains a challenge both due to a lack of data and the mismatch in the scale of movements for these smaller species and the statewide or regional analysis scale of this project.

Data description: We used mapped range data for 83 Species of Greatest Conservation Need (SGCN) identified in the 2015 State Wildlife Action Plan (WDFW 2015) that had documented occurrences and associated spatial range data. We created two versions of the SGCN data. For the Transportation analysis, we used an SGCN layer that excluded non-listed, flying birds because transportation crossing structures are primarily aimed at supporting terrestrial species. In the Landscape analysis, we retained all flying birds, but down weighted their scores by 0.75 due to the plan's focus on terrestrial connectivity. These two layers were used to create slightly different final connectivity values layers, one (excluding non-listed, flying birds) that was used for the transportation analysis and the other (including non-list, flying birds) used to inform landscape connectivity prioritization products and decisions. The connectivity values map displayed in this report include non-listed flying birds (Figure 29).

To ensure data accuracy, we exclusively utilized observed species ranges, defined using WDFW occurrence data collected between 1978 and 2015 and delineated based on the USGS Hydrologic Unit Code (HUC) 12 watershed classification system. A HUC 12 watershed was considered part of a species' initial range if species occurrence was recorded within it. These preliminary ranges were subsequently reviewed and refined by WDFW species experts to represent the most current and certain depiction of recently occupied habitat. Detailed methodology regarding the development of SGCN ranges can be found in Appendix B of the 2015 SWAP. Species were weighted based on their Federal and State protection status and inclusion in the WDFW Priority Habitats and Species (PHS) list. Locations with a greater number of species and/or those that are more rare or endangered, received higher connectivity value scores.

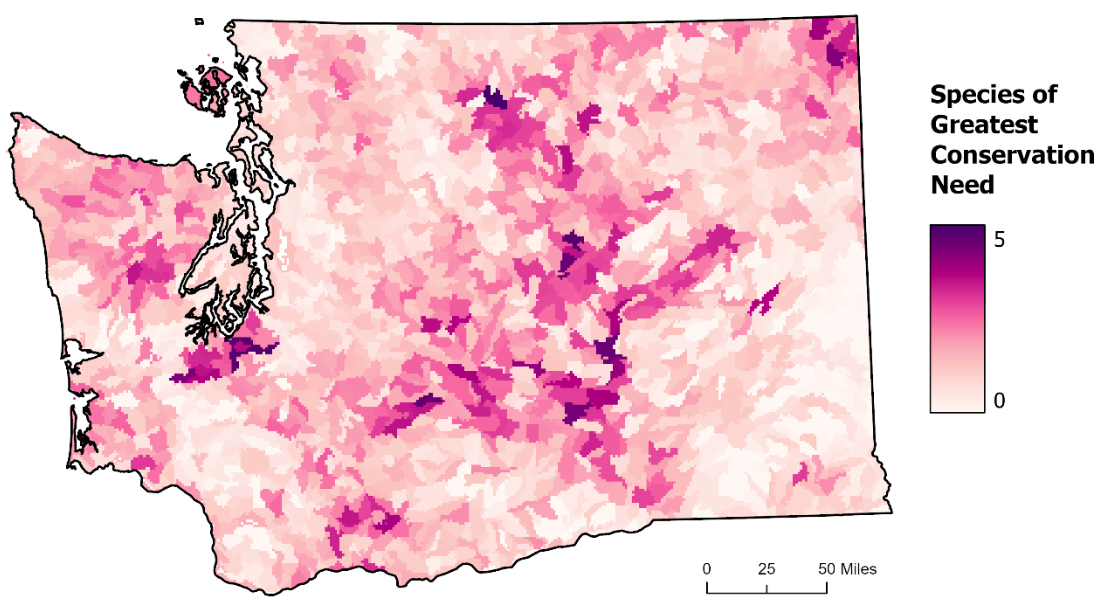

Figure 29. Species of Greatest Conservation Need input layer.

Climate connectivity (Input layer 8)

Purpose: Habitat connectivity is essential to allow wildlife to move through the landscape as needed to track changing climatic conditions (Heller and Zavaleta 2019). Although all connectivity is helpful to this process, some movement routes and corridors are likely to be more important to facilitating species range shifts that track changing climatic conditions

(Littlefield et al. 2017). As a result, including connectivity models that explicitly consider climate-driven range shifts is important to capture these dynamics.

Data description: To represent how landscape characteristics might facilitate or impede species movement under various climate change scenarios, we utilized a continent-wide model for North America published by Parks et al. (2020). This model identifies pathways that track shifting climatic conditions while also avoiding present-day human landscape modification (Figure 30).

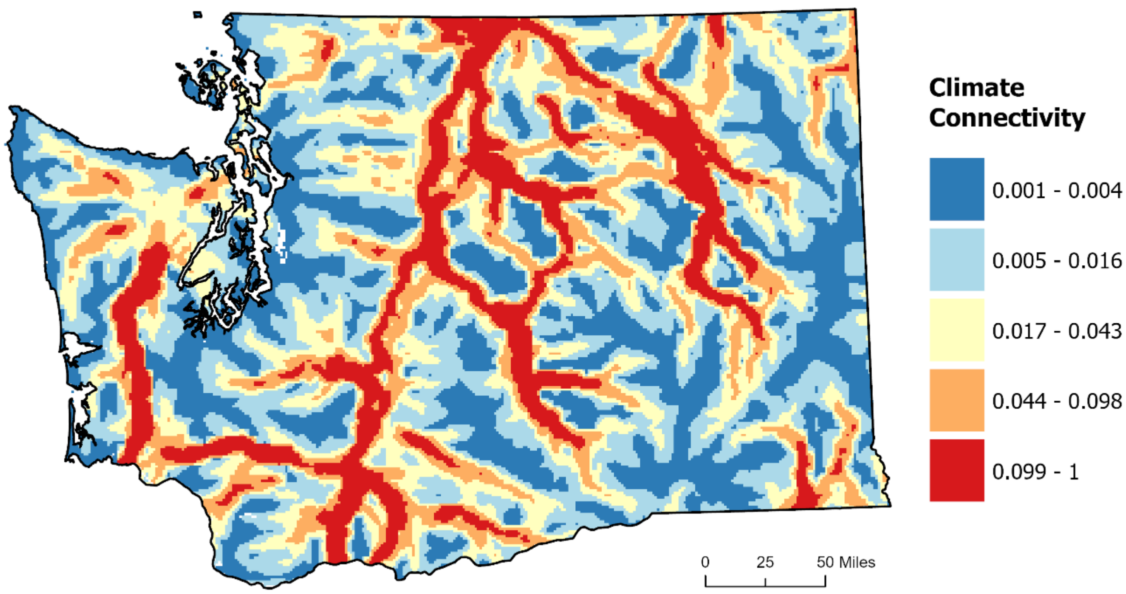

Figure 30. Climate Connectivity input layer.

Columbia Plateau Existing Prioritizations (Input layers 9 and 10)

Purpose: Three habitat connectivity-based prioritizations have already been conducted for the Columbia Plateau ecoregion in Washington State. Each of these prioritizations was created for a slightly different objective, but all seek to achieve a similar broad goal consistent with the WAHCAP: to identify large, intact core areas of important habitat for shrubsteppe species and areas of connectivity between those core areas. Our TAG reviewed all three prioritizations and found that they identify many of the same locations, but each one also identified unique areas that weren't included in the other two analyses. We were unable to discard any of these three as invalid or outdated based on our review of their methods and their representation of the current landscape. Consistent with our guiding principle to reflect existing, scientifically valid, conservation priorities in our prioritization, we decided to include all three. Because of the significant spatial overlap among the three, we were careful to adjust how these were incorporated into the prioritization to minimize the impacts of double counting.

Arid Lands Initiative and PHS Biodiversity Areas and Corridors (Input layer 9)

Purpose: The Arid Lands Initiative (ALI) and WDFW's PHS program Biodiversity Areas and Corridors (BACs) both used landscape connectivity and focal species connectivity models from the Columbia Plateau connectivity analysis (WHCWG 2012) to create synthesized maps of important core and connectivity locations. Because of their similarities, we combined them into a single metric.

Data description: This metric combined two existing spatial prioritizations in the Columbia Plateau (Figure 31). The first was the Arid Lands Initiative (ALI), which mapped priority Core Areas and Linkages using 500-acre hexagons (ALI 2014). The second was WDFW's Biodiversity Areas and Corridors (BACs) mapped for the Columbia Plateau at a 30-m resolution (WDFW 2023). Because of their similarities, we combined them into a single metric, where 1-mile grid cells that contained both ALI and BAC priorities received a score of 5, cells that contained only BAC priorities received a score of 4, cells that contained only ALI priorities received a score of 3, and those with neither ALI nor BAC priorities received no score.

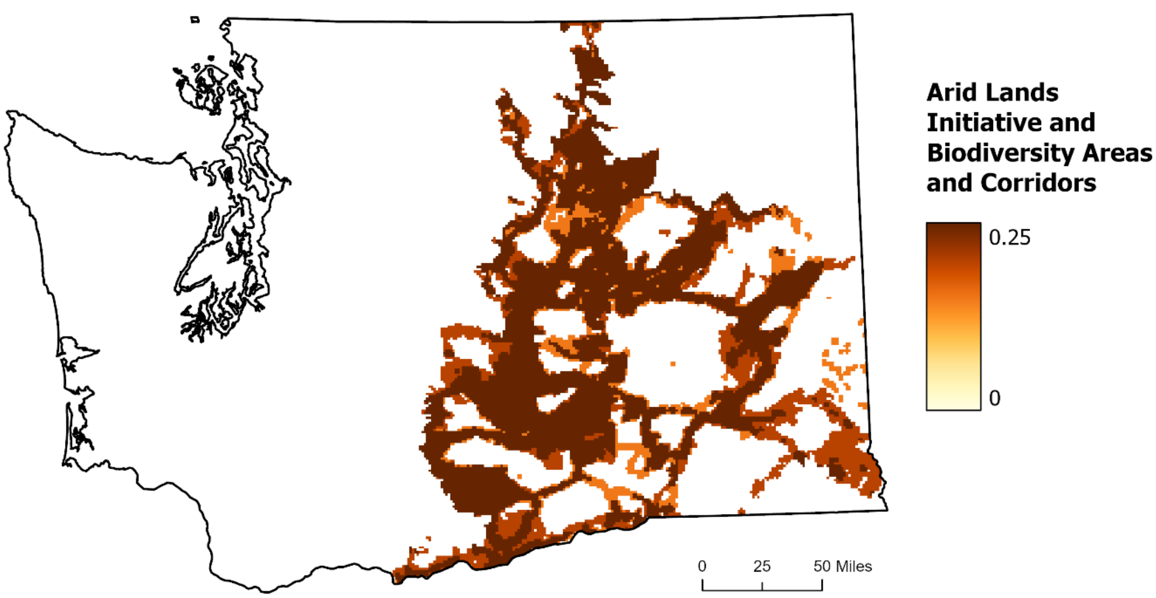

Figure 31. Arid Lands Initiative (ALI) and PHS Biodiversity Areas and Corridors (BAC) input layer.

Washington Shrubsteppe Restoration and Resilience Xeric and Mesic Habitat Priorities (Input layer 10)

Purpose: The Washington Shrubsteppe Restoration and Resiliency Initiative (WSRRI) created maps of spatial priorities for dry (xeric) ecosystems and wet (mesic) ecosystems in the Columbia Plateau ecoregion. These data were created by TerrAdapt using methods that were extremely similar to the Shrubsteppe ecosystem data developed for WAHCAP. Initially, we expected to use the WSRRI data as our Shrubsteppe ecosystem model, but after creating ecosystem models for the other forest ecosystem we found several changes were needed to meet the objectives of this project.

1. In the WSRRI data, roads were given a very high resistance value to the point that most roads were considered complete barriers to connectivity and no corridors were mapped that crossed roads. This was problematic to meeting our objective of identifying priority road crossing locations.
2. The WSRRI habitat category of "growth opportunity areas" did not translate well to the three forested ecosystems in the state. Instead, we developed the 3-tier approach for the forested ecosystems and then found that mirroring that approach on the Columbia Plateau would provide important additional data and nuance.
3. The WSRRI core areas were created to identify locations with the highest quality shrubsteppe locations. In WAHCAP, we had a broader objective, and our revised thresholds allowed for some cores to form in locations important to wildlife, but with slightly lower Shrubsteppe vegetation quality then was required for WSRRI cores.

Although we created different Shrubsteppe ecosystem data for the WAHCAP, we included the WSRRI data to ensure that we reflect those priority locations which are the focus of active conservation activity on the Columbia Plateau.

The Washington Shrubsteppe Restoration and Resiliency Initiative (WSRRI) created maps of spatial priorities for dry (xeric) ecosystems and wet (mesic) ecosystems in the Columbia Plateau ecoregion in Washington. We combined these two ecosystem priorities into a single layer depicting the highest valued habitat category from either of the two ecosystem maps (Figure 32). Cores with the highest quality habitat received a score of 2. Growth Opportunity Areas (GOAs) were more degraded than cores but still had a significant amount of habitat that could become Core with restoration; these received a score of 1. Corridors received a score of 0.5.

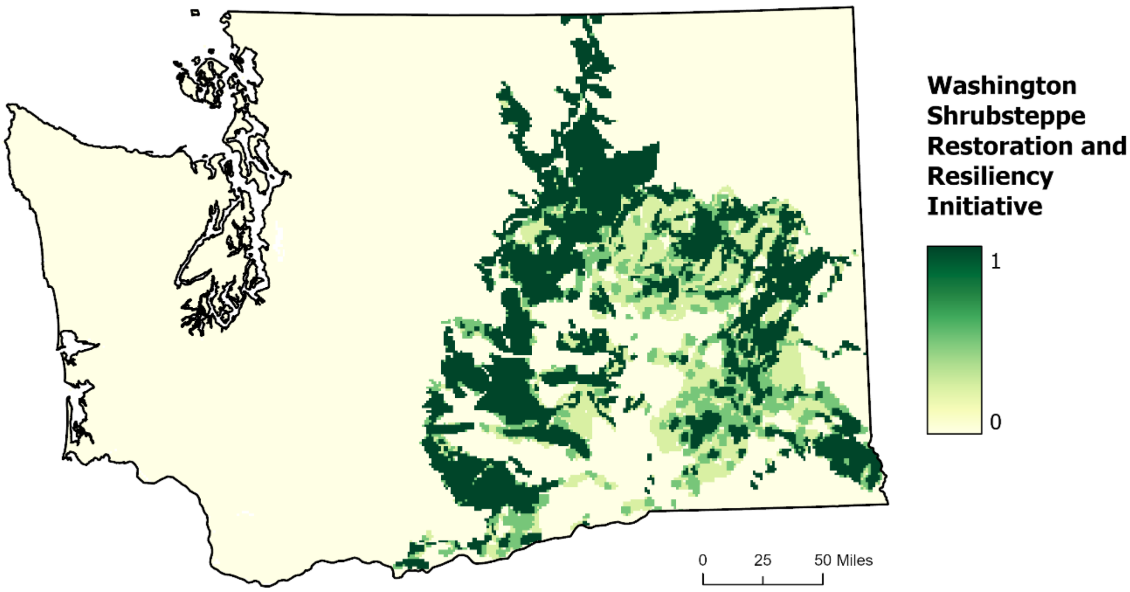

Figure 32. Washington Shrubsteppe Restoration and Resiliency Initiative input layer.

Appendix D. Transportation Connectivity Prioritization Technical Methods

Overview

The goal of the transportation prioritization process was to identify road segments and longer road Priority Zones where wildlife-vehicle collisions were a problem for motorist safety, and where landscape models and other data indicated wildlife need connectivity across existing WSDOT roads. The resulting maps, Full Highway System Rankings, and Priority Zones can be used by WSDOT and partners to identify critical areas for wildlife connectivity that should be considered in transportation planning and in standalone wildlife mitigation projects, and critical areas that are of a safety concern for motorists due to wildlife-vehicle collisions.

The WSDOT road system was divided into segments to facilitate placing values on each segment that represented various factors in the analyses. In turn, these road segments were then analyzed with respect to those factors with the ArcGIS Optimized Hot Spot Analysis tool (OHSA spatial statistic). This tool analyzes road segments based on their scores and aggregates the highest-value-scored segments. There is a fair degree of preparation of the roads GIS layer and the various data layers to conduct this analysis.

The steps in the preparation of the roads layer and the factor layers and the various OHSAs conducted are listed below and further described in this Appendix.

1. Roads Layer Preparation – divide the WSDOT roads into one-mile segments (the length) and create a buffer distance to each road segment to allow for divided highways. This is the road segment width.
2. Prepare factor input layers to quantify the values of the road, wildlife carcass removals, crashes, traffic, and landscape that will be evaluated for each one-mile road segment.
    - Ecological Value Scores
    - Wildlife-related Safety Scores.
3. Create the Ecological Value Full Highway System Rankings and Conduct an Optimized Hot Spot Analysis on Ecological Value Scores to identify Priority Zones
    a. Determine a raw Landscape Connectivity Value score for each road segment from intersection with landscape connectivity analyses one-mile pixels.
    b. Weight raw Landscape Connectivity Value scores for each segment based on traffic volume to identify Ecological Value scores for all one-mile segments, creating the Ecological Value Full Highway System Rankings.
    c. Determine the distance band, which is the search distance from the one-mile segment.
    d. Develop a long list and short list of top Ecological Value Priority Zones after conducting the Optimized Hot Spot Analysis on Ecological Value scores.
4. Create the Wildlife-Related Safety Full Highway System Ranking and Conduct an Optimized Hot Spot Analysis on the Wildlife-related Safety Scores
    a. Determine distance bands and then conduct individual OHSAs for the carcass removal data for each of the following: all deer, elk, bighorn sheep, moose, and all large carnivores.
    b. Intersect road segments with TerrAdapt cores and corridors as a surrogate for suitable large wild animal habitat.
    c. Weight one-mile segments based on species-specific hot spots and the number of reported crashes that resulted in human injuries or fatalities.
    d. Calculate the Wildlife-related Safety score for each one-mile segment, creating the Wildlife-related Safety Full Highway System Ranking.
    e. Perform a final OHSA on the Wildlife-related Safety scores to identify the top Wildlife-related Safety hot spots which are then considered Priority Zones.
5. Develop a long list and short list of Priority Zones for Ecological Value and Wildlife-related Safety.

Roads Layer Preparation

The prioritization process began by dividing the state highway system — approximately 7,000 linear miles — into standardized one-mile segments. Mainline highway line segments (2023 Washington State Linear Referencing System 24k, increasing direction) were buffered by 0.25 miles adding width to encompass divided highways. Buffers ensured off-centerline reports (e.g., from exit ramps) were captured, and spatial joins utilizing unique identifiers avoided double-counting where buffered highway segments overlapped at highway intersections. The buffered highway system was then segmented based on Accumulated Route Mileage (ARM) of individual state routes. The road system had smaller road segments (shorter than one mile) where highways terminated and at state boundaries. If these final segments were less than 0.5 miles long, they were merged with the preceding segment. Segments longer than 0.5 miles but shorter than one mile were retained without merging. In two cases (SR 41 and SR 213), the entire state highway was less than 0.5 miles, and since no preceding segment existed for merging, these segments were retained as measured.

This process resulted in 7,041 segments representing the Washington State Highway system, with a mean segment length = 0.999 miles:

- 6,750 segments = 1 mile long
- 145 segments < 1 mile long
- 146 segments > 1 mile long

Each segment received a unique identifier (IDSRARM) composed of the three-digit State Route identification code and the ARM value rounded up to the nearest integer. This uniform segmentation provided a consistent spatial framework across the state, enabling direct comparisons between segments, defining bounding polygons for subsequent data application and hot spot analyses, and providing a standardized measurement unit compatible with WSDOT planning efforts.

Evaluation of Roads with Respect to Ecological Value and Wildlife-Related Safety

Following segmentation, each one-mile state highway segment was independently assessed in two categories:

- **Ecological Value**: A measure of biodiversity with an emphasis on connected networks of habitat.
- **Wildlife-related Safety**: A measure of wildlife-vehicle collision potential.

This dual framework enabled the identification of priority areas where roads significantly fragment important habitats, frequently experience wildlife-vehicle collisions, or both, and aligns with previous prioritization frameworks at WSDOT (Habitat Connectivity Investment Priorities), and therefore conforms to established policy and decision-making processes.

Integration of Landscape Units and Ecological Value Highway Segment Scores

Raw Landscape Connectivity Value Score

The standardized one-mile highway segments served as the fundamental spatial units for the transportation analysis. One-square-mile landscape units derived from the Landscape Connectivity Value analysis were used to evaluate each highway segment's Ecological Value scores. Specifically, each highway segment received a raw Landscape Connectivity Value score equal to the average of Landscape Connectivity Value scores from all intersecting landscape units (Figure 33). Raw Landscape Connectivity Value scores per highway segment ranged from 0 to 21.17, with a mean of 7.02 and median of 5.98. These values were subsequently used to parameterize traffic volume impacts.

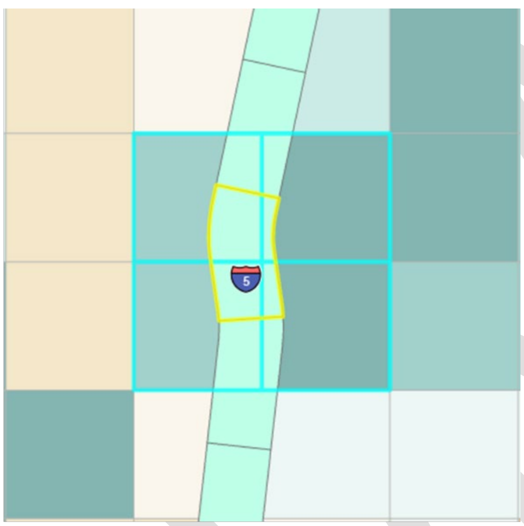

Figure 33. Raw Landscape Connectivity Value scores were applied to one-mile highway segments based on the average Landscape Connectivity Value score of all intersecting one-square-mile landscape units.

Ecological Value Score Calculation: Full Highway System Rankings

Traffic Volume Weighting

Traffic volume can be used as a surrogate for the permeability or lack thereof of a road. Wild animals of various mobilities are deterred by different levels of traffic (Charry and Jones 2009). When traffic volumes are too high, wildlife stop trying to cross the road all together which can lead to declining genetic diversity, or extirpation of populations due to lack of movement opportunities. Furthermore, highway avoidance caused by high traffic volumes leads to fewer wildlife-vehicle collisions since animals don't even attempt to cross the road, and thus the inability to identify priority crossing locations with carcass removal or crash data alone. Moderate traffic volumes are low enough to allow occasional crossings, but high enough to result in frequent wildlife-vehicle collisions. While this factor is a transportation measure, it is placed in the Ecological Value category because it helps measure the impassability of roads.

Traffic volume data (2023 Annual Average Daily Traffic, AADT) was integrated in the analysis to account for the varying impacts of highway traffic on wildlife movement. Traffic volume was used as a multiplier of the initial raw Landscape Connectivity Value score for each one-mile segment. Each one-mile segment's raw Landscape Connectivity Value score was weighted with one of five categories based on its traffic volume (Table 16).

Table 16. Traffic volume categories (Annual Average Daily Traffic, AADT) and corresponding weights applied to raw Landscape Connectivity Value scores, reflecting the increasing severity of habitat fragmentation as highway traffic volumes rise.

Traffic Volume (AADT)	**Ecological Value Score Weight**
0 – 1,999 vehicles per day AND Raw Landscape Connectivity Value Score < the mean	1
0 – 1,999 vehicles per day AND Raw Landscape Connectivity Value Score >= the mean	1.25
2,000 – 9,999 vehicles per day	1.5
≥ 10,000 vehicles per day	2
≥ 33,000 vehicles per day AND Raw Landscape Connectivity Value Score >= the median	3

Segments with less than 2,000 AADT and raw Landscape Connectivity Value scores below the mean received no weight, as these were considered permeable for most species and were adjacent to relatively lower quality habitat. Segments with less than 2,000 AADT and raw Landscape Connectivity Value scores above or equal to the mean received a weight of 1.25. Initially, no weight was applied to any segments recording less than 2,000 AADT. However, feedback during WAHCAP workshops indicated this lack of weighting undervalued key rural highways adjacent to high quality habitat in the Cascades and Columbia Plateau. Although relatively permeable to most species' movements, these segments warranted slight weighting (1.25) if raw Landscape Connectivity Value scores were greater than or equal to the mean score.

Segments experiencing moderate traffic volumes (2,000–9,999 AADT) generally present substantial impediments, though not absolute barriers, to wildlife movement. These segments received a weight of 1.5, in part reflecting the increased potential for mortalities associated with wildlife-vehicle collisions. Such mortality typically does not lead to population level effects for common species (e.g., mule deer) but poses significant risks to rare or low-density species like wolverine. Furthermore, these traffic volumes can function as complete barriers to certain low mobility species including reptiles, amphibians, and small mammals.

Segments with greater traffic volumes (≥10,000 vehicles per day) were assigned a weight of 2, recognizing that such roads pose near complete barriers to wildlife movement, significantly fragmenting habitats (Charry and Jones 2009).

A final weighting category (≥ 33,000 AADT and raw Landscape Connectivity Value scores greater than or equal to the median score) applied an even greater weight of 3 to segments. The median (rather than the mean) was used as the ecological cutoff for this category, acknowledging the generally lower-quality habitats surrounding highly trafficked highways but recognizing their importance as some of the last remaining connectivity opportunities. Approximately 10% of all segments met the traffic threshold, but only 1% simultaneously met the raw Landscape Connectivity Value score criteria greater than or equal to the median. This higher weighting targeted segments with extremely high traffic volumes adjacent to relatively high-quality habitat, highlighting locations with significant conservation value despite existing degradation from adjacent infrastructure. This category included 76 segments along two interstates – Interstate 5 (I-5) and Interstate 90 (I-90), consistent with previous frameworks and analyses, as well as WAHCAP workshop participants' input, which specifically identified portions of I-5 and I-90 as major barriers to wildlife movement.

When traffic-based weighting was applied to raw Landscape Connectivity Value scores, the resulting Ecological Value scores for each highway segment ranged from 0 to 47.653 (mean = 10.12, median= 8.99). Scores were classified into priority levels by assigning the top 10% high priority, the bottom 50% low priority, and those in between medium priority (Table 17):

Table 17. Ecological Value Full Highway System Ranking priority classification and proportional highway coverage.

Ecological Value Priority	Score Range	Number of Segments	Percent Total Linear Highway Miles
Low	0.00 - 8.990	3,521	50.0%
Medium	8.991 - 20.785	2,816	40.0%
High	20.786 - 47.653	704	10.0%

Collectively, these classifications form the Ecological Value Full Highway System Rankings, a standalone product that, together with the Wildlife-related Safety Full Highway System Rankings, serves as an update to WSDOT's existing prioritization framework, the Habitat Connectivity Investment Priorities; as well as provides the analytical foundation for identifying the Ecological Value Transportation Priority Zones.

Creation of Ecological Value Priority Zones: The Long List

A Long List of Ecological Value Priority Zones was created using an Optimized Hot Spot Analysis. This Long List of Priority Zones facilitates effective communication and decision-making among WSDOT and partners by using recognizable place names – such as cities, major rivers, or cross streets—as boundaries, rather than relying solely on highway milepost markers, which can be challenging for partners and the public to interpret.

The 7,041 weighted one-mile highway segments' Ecological Value scores were analyzed using an Optimized Hot Spot Analysis to identify statistically significant spatial clustering of high Ecological Value scores. This analysis produced contiguous stretches of highway (longer than one-mile) that shared similarities in underlying habitat quality and highway-imposed impacts – referred to as Ecological Value Priority Zones. These Priority Zones had higher average Ecological Value scores than other areas along the state highway system.

In the Optimized Hot Spot Analysis, one-mile segments were used as the input features and the Ecological Value scores were used for the analysis field, with a selected distance band (search distance) of 1.5 miles. This distance was selected to balance proportional coverage of the full highway system with the number of Priority Zones. A larger distance band resulted in more linear miles of highway identified as Priority Zones, often too many miles to represent a meaningful prioritization. Conversely, a smaller distance band resulted in overly fragmented zones that could exclude strategically important segments at zone boundaries. For instance, segments at the ends of a Priority Zone might represent the best feasible locations for wildlife crossing structures, even if the peak Ecological Value score occurred in the zone's center. A smaller distance band might omit these key end segments, reducing implementation flexibility. Through iterative testing, a 1.5-mile distance band offered the optimal spatial balance between statewide coverage, number of Priority Zones, and practical mitigation flexibility.

The hot spot analysis classified all 7,041 one-mile highway segments into statistically significant hot spots or cold spots at the 90%, 95%, or 99% confidence intervals. This confidence level indicates how strong the evidence is that the hot spot identified was truly a hot spot for the values evaluated. Segments without significant clustering were considered not significant. This analysis resulted in:

- **Hot spots:** 814 segments
- **Cold spots:** 634 segments
- **Not significant:** 5,593 segments

Segments identified as hot spots at the 90% confidence interval and higher were exported to a separate dataset, retaining key attributes. Boundaries between adjacent hot spot segments were dissolved, with attributes either summed or averaged using GIS field mapper options within the ArcGIS Pro Dissolve tool, resulting in 131 initial segments. One particularly long segment along I-90 in the Cascades (46 miles) was split into two Priority Zones at the Cascade's crest, yielding a final statewide count of 132 overall segments.

Segments must be two miles long or greater and exceed a specific Ecological Value score threshold to become Ecological Value Priority Zones. The minimum length requirement is because the Full Highway System Rankings identify priorities at the one-mile-long level and should be utilized when working at this scale, while Priority Zones aggregate high scores across longer lengths of highway. To align with the scale of the Full Highway System Rankings and ensure meaningful delineation, segments less than 2-miles-long were removed, eliminating 29 segments. Additionally, the hot spot analysis occasionally produced "spillover" effects, identifying low-scoring segments from adjacent highways due to their proximity to high-scoring highways. To address this, segments with an average Ecological Value score less than 20 were removed (the score of 20 represented the lowest threshold rounded down from the minimum high-priority one-mile segment).

After these refinements – removing 29 segments under two miles and seven low-scoring spillover segments – a total of 96 Ecological Value Priority Zones were identified.

The final 96 Ecological Value Priority Zones (Appendix B. Transportation Connectivity Priority Zones) ranged in length from 2 to 42 miles (mean=7.98 miles) and encompassed approximately 11% of the full state highway system's linear miles. Ecological Value scores for Priority Zones ranged from 20.36 to 34.43 (mean=22.88) and AADT ranged from 260 to 67,667 (mean=7,222). These 96 Ecological Value Priority Zones, together with the 60 Wildlife-related Safety Priority Zones described below, collectively form the WAHCAP transportation analysis Long List.

Wildlife-Related Safety

The Wildlife-related Safety category of the WAHCAP transportation analysis assessed wildlife-vehicle collision potential along highways. It primarily relied on wildlife carcass removal data and wildlife-vehicle collision reports from a five-year period (2019-2023), identifying locations where targeted mitigation could significantly reduce wildlife-vehicle collisions and thus provide for greater motorist safety while reducing wildlife mortalities.

Input Data

Wildlife Carcass removal records served as the primary indicator of wildlife-vehicle collision frequency and wildlife activity along state highways. These records are predominantly collected by WSDOT maintenance staff when an animal carcass is removed from the roadway. Carcass removal reporting at WSDOT began in 1973, with consistent revisioning improving data collection over time. Since 2015, WSDOT maintenance crews have used tablets to record carcass removals directly in the field, documenting species, state route, and milepost. These data are initially stored in the Highway Activity Tracking System (HATS) and subsequently transferred weekly to WSDOT's Wildlife Carcass Removal Database (WCRD). WSDOT biological staff assesses each record for spatial accuracy, species distribution, and confirms reports of rare species. If inconsistencies or rare species are reported, WSDOT biological staff follow up with maintenance staff for clarification.

Beginning in 2016, a state law authorized citizen collection of deer and elk carcasses from vehicle collisions ("citizen salvage"). Citizens must obtain a free salvage permit by reporting the location of the salvaged animal to WDFW's online system. These citizen salvage reports, previously reported solely by WSDOT staff, are reviewed by WSDOT biological staff in cooperation with WDFW for accuracy before integration into the WCRD. Consequently, carcass removal data utilized in the Wildlife-related Safety category includes both WSDOT-reported carcass removals and citizen-reported salvage data for deer and elk, each assessed for accuracy.

The analysis focused specifically on large-bodied species capable of posing a significant safety threat to motorists when involved in a wildlife-vehicle collision (Table 18). Species included black-tailed deer, white-tailed deer, mule deer, Columbian white-tailed deer, elk, moose, bighorn sheep, black bear, cougar, bobcat, wolf, and wolverine. Mountain goats and pronghorn were excluded due to low sample sizes (one and five, respectively). For modeling purposes, all deer species were combined under one category called "deer," while large carnivores (black bear, cougar, bobcat, wolf, and wolverine) were grouped to enhance statistical robustness in the subsequent hot spot analyses, although treated individually in the final Wildlife-related Safety score calculation.

Table 18. Carcass removals of large-bodied animals reported on state highways between 2019-2023 utilized in the Wildlife-related Safety model.

Species/Group	Carcass Removal Count
Deer	21,269
Elk	1,312
Black Bear	84
Moose	74
Bobcat	64
Bighorn Sheep	41
Cougar	20
Wolf	3
Wolverine	1
Total	**22,868**

Wildlife-Vehicle Collision reports ("crash data") from the Washington State Patrol supplemented carcass removal data and provided details on human injuries and fatalities resulting from wildlife-vehicle collisions between 2019 and 2023. Crash reports are few due to only being required when a human injury occurs, or damage is estimated to exceed $1,000; therefore, carcass removal data is utilized in most analytical processes (e.g. OHSA), while crash data is included to provide additional granularity. The crash reports included species of wildlife involved, though provided limited detail, reported as "deer", "elk", or "all other non-domestic wildlife." The analysis utilized all deer and elk crash data but omitted "all other non-domestic wildlife" records. Human injury and fatality statistics were included regardless of the species reported (Table 19).

Table 19. Wildlife-vehicle collision *crash reports that included indications of large-bodied wild animals and those that included human injuries and fatalities resulting from wildlife-vehicle collisions between 2019-2023 that were utilized in the Wildlife-related Safety model.*

Human Impacts	Injury/Fatality Count
Injury	659
Fatality	6
Total	**665**
Species/Group	**Crash Report Count**
Deer	5,994
Elk	682
Total	**6,676**

The **TerrAdapt Ecosystem Tiers Base Map** was incorporated into the analysis to identify highway segments intersecting ecologically significant large animal habitats. This ensured that segments passing through suitable large wild animal habitat were not inadvertently omitted from the prioritization in the absence of carcass removal and collision records. These areas were accounted for by selecting highway segments that intersected TerrAdapt-identified ecosystem cores and corridors and assigning a score of one. One-mile segments that did not intersect with the ecosystem cores and corridors layer were assigned 0 points. This single point, or lack of, was incorporated into the Wildlife-related Safety score calculation outlined in Figure 34.

The primary goal of this process was to allow segments passing through large animal habitat to be classified as Low Priority rather than No Rank in the absence of carcass removal and crash records, since the potential for a wildlife-vehicle collision is present if the habitat is. Otherwise, these segments would receive a total Wildlife-related Safety score of 0 and be classified as No Rank. For example, many one-mile segments on US Highway 101 on the Olympic Peninsula recorded 0 carcass removals or crash reports between 2019-2023. Since this highway passes through millions of acres of temperate rainforests within National Forest and Park boundaries, it is realistic to assume a wildlife-vehicle collision is possible, and more appropriate to rank these areas Low Priority within the Wildlife-related Safety category.

Integration of Wildlife-Related Safety Data and One-Mile Highway Segments

The Wildlife-related Safety analysis utilized the 7,041 standardized one-mile highway segments previously developed. Carcass removal and crash point data were assigned unique identifiers (IDSRARM) using the reported three-digit State Route identification code and ARM value rounded up to the nearest integer. These identifiers were used to spatially join carcass removal and crash point data to the buffered one-mile highway segments (0.25-mile buffers). Human injury and fatality records were appended similarly, and segments intersecting TerrAdapt-identified ecosystem cores and corridors received a binary modifier and were assigned one point, while segments outside cores and corridors received zero points.

Weighting by Species or Group-Specific Carcass Removal Hot Spots, and Human Injuries and Fatalities Resulting from Wildlife-Vehicle Collisions

Carcass Removal Hot Spots and Weighting Based on Species or Group

Individual hot spot analyses were performed for each of five species or groups: all deer (a combination of black-tailed, white-tailed, Columbian white-tailed, and mule deer), elk, bighorn sheep, moose, and large carnivores (black bear, bobcat, cougar, wolf, and wolverine). Incremental spatial autocorrelation (ISA) Identified optimal distance bands for each group to maximize spatial clustering (Table 20). When two peak distances were identified with ISA, typically the larger distance was used to intentionally broaden coverage of hot spots, since the goal was to weight features like carcass removal and crash reports rather than delineate standalone hot spots. The number of carcass removals per segment were used as the analysis field – this treats the one-mile segments as weighted features, the frequency of carcass removals being the weight in this case, when initial species-specific hot spots were identified.

Table 20. Distance bands for individual species or group-specific hot spot analyses.

Species/Group	Distance Band (ft)	Equivalent Miles
Deer	18,480	3.5 miles
Elk	16,500	3.1 miles
Bighorn Sheep	58,296.08	11.0 miles
Moose	21,611.66	4.1 miles
Large Carnivores	21,611.66	4.1 miles

Results of individual species or group-specific hot spots are reported in Table 21. Relevant attributes (Z-Score, P Value, and Gi Bin) from the hot spot analyses were spatially joined to the one-mile highway segment layer, and segments identified as hot spots were classified as within a hot spot or outside a hot spot using hot spots identified at the 90% confidence interval and higher for that particular species or group.

Table 21. Number of cold spots, hot spots, and non-significant segments resulting from species and group-specific hot spot analyses for 90% confidence interval and higher.

Species/Group	Cold Spots (segments)	Not Significant (segments)	Hot Spots (segments)
Deer	257	6,004	780
Elk	0	6,648	393
Bighorn Sheep	0	6,840	201
Moose	0	6,878	163

Large Carnivores	0	6,766	275

These 90, 95, and 99% Confidence Interval hot spots for each of the species or groups were then weighted according to the species. Segments identified as hot spots were assigned species-specific or group weights. Since deer accounted for approximately 93% of total carcass removal records used in this analysis, they would dominate final scoring without differential weighting to make up for this overabundance of deer carcasses in relation to other species. Therefore, species with lower carcass removal occurrences received higher relative weights, ensuring a balanced representation of all species and groups in the Wildlife-related Safety score.

Weighting by Human Injuries and Fatalities Resulting from Wildlife-vehicle Collisions

An additional factor in the weighting of the Wildlife-related Safety score involved locations where human injuries or fatalities resulted from wildlife-vehicle collisions. This aligns with WSDOT's mission to provide and support safe transportation options. This process augmented scores by giving the locations of crashes with human injuries or fatalities distinct additional weights, with locations recording multiple human injuries being weighted more heavily, as these could be indicative of site conditions that lead to more severe accidents (Table 22).

Table 22. Weighting for species or group-specific hot spots and human injuries and fatalities resulting from wildlife-vehicle collisions.

Feature	Weight
Deer Hot Spot	2
Elk Hot Spot	5
Moose Hot Spot	8
Bighorn Sheep Hot Spot	8
Large Carnivore Hot Spot	8
One Human Injury	2
Multiple Human Injuries	8
Human Fatality	16

The structured weighting approach effectively highlighted priority highway segments posing the highest collision risk across all wildlife species or groups, while incorporating human safety considerations.

Wildlife-Related Safety Calculation: Full Highway System Rankings

The Wildlife-Related Safety score for each one-mile highway segment was calculated as a **weighted sum** of carcass removals, crash reports, human injuries, and fatalities. Species-specific weights for deer, elk, moose, bighorn sheep, and large carnivores were only applied to the sum of that particular species' carcass removal and crash reports if incidents occurred within identified species- or group-specific carcass removal hot spots. Segments with human injuries received higher weights when multiple injuries occurred within a single segment. Additionally, segments intersecting the TerrAdapt ecosystem cores and corridors binary surface received an incremental (1) point.

Carcass removals and crash reports were first summed by species, appropriate weights were applied if within an identified carcass removal hot spot, then weighted scores were summed. Similarly, human injuries and fatalities were summed per segment, appropriate weights were applied, then weighted scores were summed. The sums of the weighted carcass removal and crashes were added to the sums of the weighted human injuries and fatalities, and finally, a point for being within suitable large animal habitat was added as necessary.

For each one-mile segment, the score was calculated as follows (Figure 34); a visual depiction is provided in Figure 35:

$$(sum\ of\ deer\ carcass\ removals\ and\ crash\ reports) * 2\ if\ in\ deer\ hot\ spot$$

$$+$$

$$(sum\ of\ elk\ carcass\ removals\ and\ crash\ reports) * 5\ if\ in\ elk\ hot\ spot$$

$$+$$

$$sum\ of\ moose\ carcass\ removals * 8\ if\ in\ moose\ hot\ spot$$

$$+$$

$$sum\ of\ bighorn\ sheep\ carcass\ removals * 8\ if\ in\ bighorn\ sheep\ hot\ spot$$

$$+$$

$$sum\ of\ large\ carnivore\ carcass\ removals * 8\ if\ in\ large\ carnivore\ hot\ spot$$

$$+$$

$$sum\ of\ human\ injuries * 2\ if\ only\ one\ per\ segment; * 8\ if\ 2\ or\ more\ per\ segment$$

$$+$$

$$sum\ of\ human\ fatalities * 16$$

$$+$$

$$1\ if\ segment\ intersects\ TerrAdapt\ ecosystems\ cores\ and\ corridors\ binary\ surface$$

$$= Wildlife - Related\ Safety\ Score$$

Figure 34. Formula for calculating Wildlife-related Safety score per one-mile highway segment.

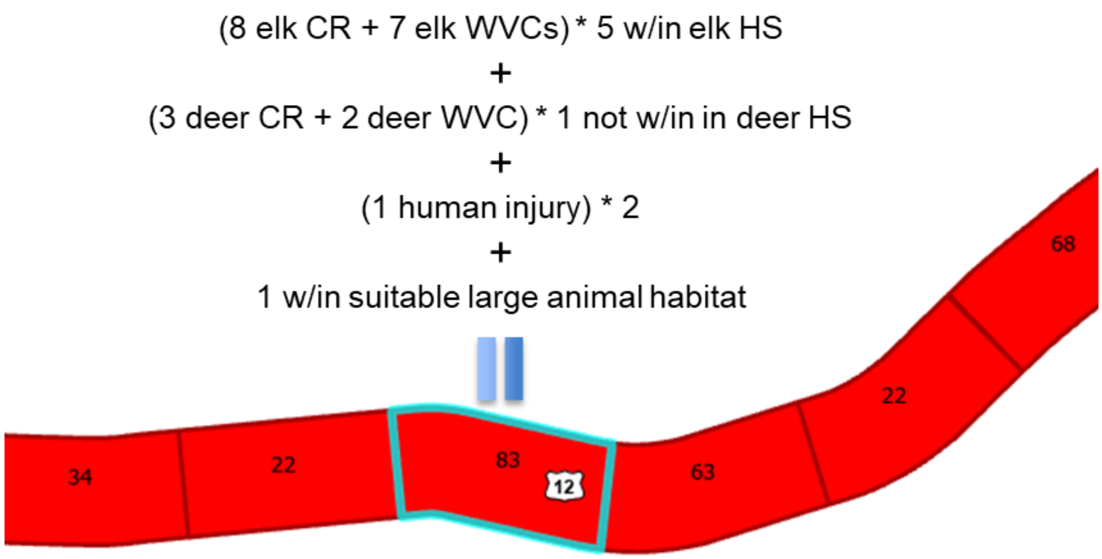

Figure 35. Visual depiction of the Wildlife-related Safety score calculation. CR = carcass removal. WVC = wildlife-vehicle collision/crash report. HS = *species or group-specific hot spot*.

This weighted sum resulted in Wildlife-related Safety scores for each one-mile highway segment (Table 23). Wildlife-related Safety scores ranged from 0 to 158 (mean = 7.63, median = 3.0). Segments were classified into priority levels as follows:

- **High Priority:** Top 10% of scores.
- **Medium Priority:** Scores between high priority and low priority thresholds.
- **Low Priority:** Bottom 51% of segments with scores ≥1 but ≤4.
- **No Rank:** Segments with scores of 0 (no reported carcass removals, crash records, and not within suitable large animal habitat).

Table 23. Wildlife-related Safety Full Highway System *Rankings priority classification and proportional highway coverage*.

Wildlife-Related Safety Rank	Score Range	Number of Segments	Percent Total Linear Highway Miles
No Rank	0	730	10.4%
Low	1 - 4	3,596	51.1%
Medium	5 - 19	2,004	28.5%
High	19 - 158	711	10.1%

Taken together, these classifications form the Wildlife-related Safety Full Highway System Rankings – a standalone product, that together with the Ecological Value Full Highway System Rankings, serves as an update to WSDOT's existing prioritization framework, the

Habitat Connectivity Investment Priorities; as well as provides the analytical foundation for identifying Wildlife-related Safety transportation Priority Zones.

Full Highway System Rankings Data Availability

All scoring inputs for the Ecological Value and Wildlife-related Safety scores are available in the GIS attribute tables available through the WAHCAP ArcGIS Online website, along with additional information that can be used for project planning to identify appropriate mitigative actions.

Counts of carcass removals and wildlife-vehicle collisions from 2019 to 2023 are provided for each one-mile highway segment, broken down by species or species group. Dividing these counts by five (the number of data years) yields a standardized annual rate of carcasses removals or collisions per mile—a commonly used metric for comparison.

To enhance prioritization, we retained hot spot identifiers from five OHSA conducted for deer, elk, moose, bighorn sheep, and large carnivores. These hot spots are used to apply weighted scores in the Wildlife-related Safety analysis, reflecting statistically significant clustering of incidents.

Species-specific hot spot fields are included in the GIS attribute table using the following naming conventions:

- “DeerHS” (deer), with the same naming convention applying to elk and moose
- “LCARHS” (large carnivores)
- “BHSHS” (bighorn sheep)

Segments with hot spot values greater than 0 (1 to 3) were identified as carcass removal hot spots for that species or group, with increasing levels of statistical confidence (1=90% Confidence, 2=95% Confidence, and 3=99% Confidence hot spots). Segments identified as hot spots received weighting factors in the scoring process to reflect their elevated importance. These attributes enable planners, researchers or managers to conduct detailed, site-specific assessments and to target mitigation actions based on species of concern and wildlife-vehicle collision patterns.

Creation of Wildlife-Related Safety Priority Zones: The Long List

The 7,041 weighted one-mile highway segments were analyzed using Optimized Hot Spot Analysis to identify statistically significant spatial clustering of high Wildlife-related Safety scores. This analysis produced contiguous stretches of highway (longer than one-mile) that shared similarities in wildlife-vehicle incident severity – referred to as Wildlife-related Safety Priority Zones.

For the Optimized Hot Spot Analysis, each one-mile segment's Wildlife-related Safety scores was used, with a distance band of 2.5 miles. Multiple iterations indicated that a 2.5-mile distance band offered the best balance of proportional statewide coverage and number of Priority Zones, while still providing broad enough coverage to allow for flexibility of mitigative implementation.

The Wildlife-related Safety hot spot analysis classified all 7,041 one-mile segments into statistically significant hot spots or cold spots at the 90%, 95%, or 99% confidence intervals; segments without significant clustering were considered not significant. This analysis resulted:

- **Hot spots:** 653 segments
- **Cold spots:** 5 segments
- **Not significant:** 6,383 segments

Segments identified as hot spots at the 99% confidence interval (493 segments) were exported to an intermediate data layer to be refined into Wildlife-related Safety Priority Zones that make up the Long List, retaining key attributes. Boundaries between adjacent hot spot segments were dissolved, with attributes either summed or averaged using GIS field mapper options within the ArcGIS Pro Dissolve tool, resulting in 94 initial segments.

Segments must be two miles long or greater and exceed a specified Wildlife-related Safety score threshold to become Wildlife-related Safety Priority Zones. The minimum length requirement is because the Full Highway System Rankings identify priorities at the one-mile-long level and should be utilized when working at this scale, while Priority Zones aggregate high scores across longer lengths of highway. To align with the scale of the Full Highway System Rankings and ensure meaningful delineation, segments less than 2-miles-long were removed, eliminating 21 segments. The hot spot analysis occasionally produces "spillover" effects, identifying low-scoring segments as hot spots due to their proximity to high-scoring highways. To address this, 13 segments with an average Wildlife-related Safety score less than 20 were removed (the score of 20 represents the lowest threshold of a high-priority one-mile segment). One Priority Zone on US 97 Alternate Route with a score below 20 was retained (score =17.29) due to it being a well-known bighorn sheep collision risk and a stated regional priority for WSDOT staff.

After these refinements – removing 21 segments under two miles and 13 low-scoring spillover segments – a total of 60 Wildlife-related Safety Priority Zones were identified.

The final 60 Wildlife-related Safety Priority Zones (Appendix B. Transportation Connectivity Priority Zones) ranged in length from 2 to 20 miles (mean=7.51 miles) and encompassed approximately 6% of the full state highway system's linear miles. Wildlife-related Safety scores for Priority Zones ranged from 17.29 to 66.67 (mean=39.89). These 60 Wildlife-related Safety Priority Zones, together with the 96 Ecological Value Priority Zones previously described, collectively form the 156 Priority Zones on the WAHCAP transportation analysis Long List.

Overlapping High Priority One-Mile Segments and Priority Zones

In addition to considering the Ecological Value and Wildlife-related Safety categories independently, it is important to evaluate where high priority areas within each of these categories overlapped. In other words, where a single one-mile segment for both categories ranked high priority within the Full Highway System Rankings, or where Priority Zones from both categories identified portions of the same roadway. This provides another layer of information by which to prioritize locations or projects using the Full Highway System Rankings, Long List, or Short List, as focusing on these areas can simultaneously improve habitat connectivity and significantly reduce wildlife-vehicle collisions. This factor was a primary consideration when determining which Priority Zones composed the Short List (see *Prioritization Methods* below).

Full Highway System Rankings Overlap

Within the Full Highway System Rankings, 67 one-mile segments ranked high priority for both Ecological Stewardship and Wildlife-related Safety. This represents approximately 5% of the 1,417.47 linear highway miles assigned high priority across both categories, and 1% of total linear highway miles in the state.

Long List Overlap

The Long List Priority Zones identified 36 miles of overlap between Ecological Value and Wildlife-related Safety, representing approximately 3% of Long List Priority Zone linear highway miles (total miles identified across both categories = 1195.21), and 0.5% of total linear highway miles in the state.

Short List Overlap

The Short List Priority Zones identified 28 miles of overlap between Ecological Value and Wildlife-related Safety, representing approximately 6% of Short List Priority Zone linear highway miles (total miles identified across both categories = 463.31), and 0.4% of total linear highway miles in the state.

This relatively low degree of overlap could be ascribed to several potential factors but is mostly likely due to the species driving prioritization within Ecological Value and Wildlife-related Safety categories. Deer carcass removal and crash reports far outnumbered any other species or group, and therefore were the strongest influence, by far, on the identification of Wildlife-related Safety priorities. Yet, deer are habitat generalists and not sensitive to the human footprint – they commonly utilize landscapes like agricultural fields, small parks, and backyards to meet their life needs. These landscape types, though not devoid of ecological value, were not prioritized within the landscape connectivity analyses that drove the Ecological Value ranks of the transportation analysis. Instead, the landscape analysis prioritized species sensitive to the human footprint, or landscapes with minimal degradation due to the human footprint. This difference in the underlying factors used to prioritize the landscape for connectivity value versus the road network for Wildlife-related Safety is likely responsible for the relatively low level of overlap documented between Ecological Value and Wildlife-related Safety priorities in the transportation analysis.

Another contributing factor could be how traffic volume influenced the identification of Ecological Value priorities within the WAHCAP, and how traffic volume affects wildlife-vehicle collision rates in general. It's hypothesized that as traffic volumes increase, wildlife-vehicle collision rates also increase until meeting a certain threshold of traffic volume, at which point, traffic volumes become so high that wildlife avoidance of the roadway increases to a level that results in decreasing wildlife-vehicle collisions, but also the inability for animals to safely cross the highway (Inman et al. 2024; Figure 36). Ecological Value priorities tended to favor highways adjacent to very high-quality habitat, or highways adjacent to relatively high-quality habitat *and* high traffic volumes. The identification of highways adjacent to very high-quality habitat was dependent on the level of human footprint within the landscape connectivity analysis' Ecosystem Cores and Corridors, which included varying levels of traffic volume. This theoretically could result in identifying Ecological Value priorities that either A) have very low traffic volumes (and thus high habitat quality) or B) relatively high habitat quality and very high traffic volumes. In these cases, areas with moderate traffic volumes and moderate habitat quality would not be emphasized in the Ecological Value priorities yet could be where deer are most active (moderate habitat quality, such as forests interspersed with large agricultural fields) and likely to be involved in wildlife-vehicle collisions (moderate traffic volumes).

These considerations illustrate the importance of utilizing both categories of the transportation analysis. Wildlife-related Safey priorities are based more around common species, as the nature of the data requires, while Ecological Value priorities are focused more on rare or low-density species and the habitats they need, which are typically not reflected in carcass removal and crash data.

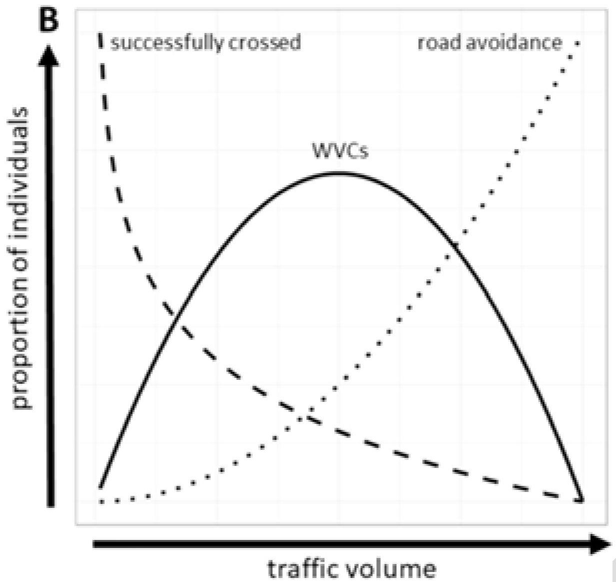

Figure 36. Hypothesized relationship between traffic volume and wildlife-vehicle collisions, figure from Inman et al (2024).

Appendix E. Landscape values technical methods

Input layer 1. Ecosystem Connectivity

Author: Andrew Shirk, TerrAdapt

TerrAdapt Data

The WAHCAP ecosystem models were developed primarily from synthesis of a time series of spatial data provided by TerrAdapt, including models of landcover, forest structure, rangeland vegetation, 30-year normal climate, and the human footprint that spanned the years 1984-2022. For details on how TerrAdapt developed these datasets, please refer to the full documentation available at https://terradapt.gitbook.io/terradapt-cascadia-documentation.

Briefly, the TerrAdapt landcover model is a discrete classification of 19 unique landcover classes including various forms of dominant vegetation communities (e.g., coniferous forest, xeric shrubland, mesic grasses and forbs, and woody wetlands), agricultural types (e.g., orchards, pastures, and irrigated row crops), natural non-vegetated lands (e.g. water, glaciers, and barren), and urban areas. In addition to the discrete classification, TerrAdapt also provides the partial probability of a pixel belonging to each class. These probabilities are generally related to the fractional cover of a pixel, such that a pixel half covered in deciduous forest and half covered in mesic shrubs would tend to have a roughly 50% probability of belonging to each of those classes.

The TerrAdapt forest structure model provides continuous measures of forest metrics such as % canopy cover, canopy height, and quadratic mean diameter. Similarly, the rangeland vegetation model provides continuous measures of the fractional cover of various rangeland vegetation types, including percent cover of invasive annual grasses, perennial grasses, shrub, and sagebrush cover. Together with the landcover model, these continuous measures of forest and rangeland vegetation were used extensively in the ecosystem models to map the vegetation component driving patterns of ecosystem habitat and connectivity.

TerrAdapt's climate models were developed using the ClimateNA algorithm (Wang et al. 2016) to downscale regional climate models to 250m resolution, providing a suite of 31 bioclimatic variables, calculated annually as the average conditions over the prior 30 years (i.e., 30-year normals). The 250 m resolution was sufficient to resolve the climatic gradients regionally and locally from mountain summits and high ridges to valley bottoms. The bioclimatic variables enabled mapping of broad ecosystem types that reflect ecological communities with broadly similar climatic niches, including similar relationships to the amount of precipitation (both rain and snow), mean annual temperature, aridity, and continentality (i.e., the moderating effect on temperature of the coastal maritime environment compared to interior areas with greater temperature extremes). These bioclimatic variables defined a climate space that served to constrain an ecosystem's habitat and connectivity to areas that were climatically suitable.

Finally, TerrAdapt's human footprint model was used across the ecosystem models to quantify the impact of human activities on habitat and connectivity. These models reflected the cumulative effects of a variety of stressors, including the impacts of the transportation and energy infrastructure (e.g., various road types, transmission lines, wind turbines, solar farms, pipelines, and surface mines), agriculture, forestry, urbanization, and recreation (e.g., ski areas, campgrounds, and trails). These impacts were represented in the models as site-level impacts (e.g., the impact of the paved road) as well as distance effects that radiated out from the site. The distance and magnitude of those effects were scaled to account for the types of human activities, noise and light, invasive species, pollution, and other area effects that tend to coincide with the impacts at the site. The human footprint index quantified the cumulative impacts of these site and area effects from all stressors, yielding a continuous index scaled from 0-1, with a value of 0 being no human modification detected and a value of 1 indicating completely modified habitat.

In addition to the human footprint index, TerrAdapt also provides a model reflecting the impacts of the human footprint on movement (i.e., a 'resistance' model) that was derived similarly from the same inputs, but with different parameters reflecting the fact that some human activities may result in poor habitat quality, but still provide some measure of permeability to movement (e.g., an irrigated agriculture field may not be habitat to many species, but many species have at least some capacity to move across fields as they disperse between habitat patches). The resistance model was scaled from 1 (no additional resistance to movement beyond the effect of distance alone) to 1000 (a pixel of this value was a complete barrier to movement and could not be traversed). Resistance values act as multipliers, such that a value of 5 means it is 5 times more 'costly' to move (in terms of energetics, behavioral avoidance, and risk of mortality) compared to ideal movement habitat where the only 'cost' is the resistance due to distance alone.

Importantly, the landcover, forest and rangeland vegetation, climate, and human footprint inputs into the ecosystem models are dynamic datasets that are produced annually starting in 1984 and updated each year. Using all available data at the time of this analysis, the ecosystem models represent a synthesis of data from 1985 to 2022. This temporal view of the landscape enabled mapping of ecosystem habitat and connectivity such that areas with ephemeral disturbances (e.g. wildfires removing forest, followed by regeneration) were not included as drivers of ecosystem habitat quality and connectivity. Instead, the models were driven more by permanent anthropogenic disturbances like urbanization and conversion to agriculture.

Ecosystem Extents, Types, and Tiers

We defined a broad study area for mapping the ecosystems that included the full extent of TerrAdapt's input data and spanning all of Washington as well as parts of neighboring states and provinces (Oregon, Idaho, Montana, and British Columbia). This provided a buffer beyond the state border and facilitated a transboundary understanding of patterns of habitat and connectivity. Within this extent, we identified and mapped 4 ecosystems including:

1. Temperate forests distributed along the lower elevation coastal areas of western Washington, Oregon, and British Columbia.
2. Montane mesic forests distributed across the higher elevations of the Olympic and western Cascade Range in Washington as well as the western Coast Range in British Columbia, and the higher elevations of the Rockies, Kettle Range, Selkirks, Blue Mountains, and Wallowas.
3. Montane xeric forests distributed across the eastern side of the Cascade Range in Washington as well as the eastern side of the Coast Range in British Columbia and much of the lower to mid-elevation forests in the Rockies, Kettle Range, Selkirks, Blue Mountains, and Wallowas.
4. Shrubsteppe habitat distributed across the Columbia Plateau in Washington and extending up the Okanogan Valley into British Columbia.

We based habitat and connectivity for each ecosystem on ecosystem-specific preferences for climate and vegetation as well as avoidance of the human footprint. For example, the temperate forest ecosystem was parameterized such that high quality habitat and corridors were constrained to occur in areas with a temperate climate, predominantly forest vegetation, and without high degrees of urbanization, agriculture, and infrastructure. The shrubsteppe ecosystem was constrained to occur within areas of an arid climate, with predominantly shrubsteppe vegetation, and without high degrees of urbanization, agriculture, and infrastructure.

Within each ecosystem, we mapped 3 different 'tiers' of habitat cores and corridors reflecting a range of sensitivities to suboptimal climate, vegetation, and exposure to the human footprint. The Tier 1 models represented specialists within the ecosystem that are highly sensitive to suboptimal conditions. The Tier 3 models represented more generalist species within the ecosystem that have far greater tolerance for suboptimal climate, thrive in a more diverse mosaic of vegetation types, and have greater tolerance of human modified landscapes. The Tier 2 models represented an intermediate degree of tolerance. Together, the 3 tiers allow for a diverse suite of selection behaviors to be represented, and facilitates comparison of areas that are only likely to be used by specialists versus areas on the urban fringe that may be compatible with species that have higher tolerances.

Ecosystem Habitat

We quantified habitat quality for each of the 3 tiers within each of the 4 ecosystems as a function of the interacting effects of climate, vegetation, and the human footprint. Each of the 3 elements is described in the sections below, followed by descriptions of methods we used to combine these elements into models of ecosystem habitat quality, resistance, and core habitat.

Ecosystem Climate

We mapped ecosystems in climate space using a clustering algorithm on 5 bioclimatic variables for the year 2022, obtained from the downscaled 250m data described in the TerrAdapt Data section above. The variables included mean annual temperature (MAT), mean annual precipitation (MAP), potential evapotranspiration ratio (PETr), annual precipitation as snow (PAS), and temperature differential (TD). The first three variables are used in the calculation of Holdridge Life Zones (ref) and have been shown to be strongly related to observed ecosystem distributions globally (ref). The addition of PAS and TD added additional context useful in resolving the maritime influence on the coastal temperate forests and the effects of annual snowfall in separating the temperate from the montane forest ecosystems.

We used a k-means clusterer implemented in Google Earth Engine with the number of clusters set to 11 based on an initial exploratory analysis that revealed 11 clusters was the minimum needed to resolve the 4 regional ecosystems of interest for this study. The clusterer was trained on the 5 bioclimatic variables above extracted at 10,000 point locations randomly distributed across the study area. We then reclassified the 11 clusters, rolling them up into the 4 ecosystems based on our expert knowledge of the regional landscape.

To map the climatic suitability of each ecosystem on a continuous 0-1 scale, we assigned all pixels within the ecosystem bounds a value of 1 (perfectly suitable climate). For the Tier 1 models, we calculated climatic suitability outside the ecosystem initially as a function of the square of the relative departure of the climate relative to the 5th and 95th percentile of values sampled from within the ecosystem bounds. For example, if the MAP in a pixel outside the ecosystem was half the 5th percentile, suitability was (departure = 0.5) ^ 2 = 0.25. If the precipitation was double the 95th percentile of the ecosystem, suitability was 1 / (departure = 2) ^ 2 = 0.25. The final Tier 1 suitability for each ecosystem was then calculated as the product of the transformed departures for all 5 bioclimatic variables. We calculated Tier 2 climatic suitability as the square root of the Tier 1 climatic suitability. We calculated Tier 3 climatic suitability as the square root of the Tier 2 climatic suitability.

Ecosystem Vegetation

Each ecosystem was associated with a broad vegetation type. The 3 forest ecosystems were all driven by the same association with forests, intentionally defined loosely to encompass a spectrum of environments from dense forests to open and/or patchy forests in a mosaic of other natural landcover types (e.g. forests and grasslands or shrublands). The quality of habitat within a forest ecosystem was partly driven by the focal mean % forest canopy cover within a 500m moving window. The highest suitability (1.0) was given to pixels with a mean canopy cover of > 50%. Tier 1 vegetation suitability decreased linearly from 1 to 0 as canopy cover decreased below 50%. We calculated Tier 2 vegetation suitability as the square root of the Tier 1 vegetation suitability. We calculated Tier 3 vegetation suitability as the square root of the Tier 2 vegetation suitability.

Importantly, the canopy cover used in the above calculation was calculated as the maximum canopy cover observed at any time over the period 1984-2022. In this way, transient forest losses would not negatively affect suitability (though forest loss associated with timber harvest, agriculture, urbanization, and other anthropogenic activities reduced suitability in the model when the human footprint was added along with vegetation and climate to derive the final model of ecosystem habitat quality.

We quantified the shrubsteppe ecosystem's vegetation quality as a function of 3 variables all calculated as the mean value within a 250m radius circular moving window:

1. The proportion of native grasses and xeric shrubs based on the TerrAdapt landcover model, averaged over the years 1984-2022. Areas with a value of 1 were entirely native shrubsteppe vegetation for the entire time series.
2. The mean % cover of invasive annual grasses over the most recent 5-year period (2018-2022). This was transformed such that values < 10 % cover has a value of 1 and suitability decreased in a sigmoidal relationship at a maximum value of 50% cover.
3. The mean % canopy cover over the most recent 5-year period (2018-2022). This was transformed such that values < 20 % cover has a value of 1 and suitability decreased in a sigmoidal relationship at a maximum value of 60% cover.

We calculated Tier 1 shrubsteppe vegetation suitability as the product of the 3 inputs above. We calculated Tier 2 vegetation suitability as the square root of Tier 1 vegetation suitability. We calculated Tier 3 vegetation suitability as the square root of Tier 2 vegetation suitability.

Human Footprint

We based the human footprint component on TerrAdapt's dynamic human footprint model described above. The human footprint influenced habitat suitability in the same way for all 4 ecosystems, and for Tier 1 models, we calculated it as:

1 - human footprint index

For Tier 2 models, we calculated human footprint suitability as the square root of the Tier 1 quality. Tier 3 suitability was the square root of Tier 2 suitability.

Habitat Quality

We assessed habitat quality for an ecosystem as the product of the climatic suitability, vegetation suitability, and human footprint suitability inputs described above. Because each of the 3 components were scaled from 0 to 1, the final output was also scaled 0 to 1. Using the product to combine the 3 components into a single model had the effect of amplifying the effects of suboptimal climate, vegetation, or human footprint, clearly resolving the comparatively few pixels that were highly suitable in all 3 dimensions.

The Tier 1 habitat quality models used the most stringent Tier 1 definitions of the 3 inputs, while the Tier 2 and Tier 3 models used the increasingly more relaxed definitions, reflecting species that were less sensitive to climate, vegetation, and the human footprint. In this way, the 3 tiers of habitat quality for an ecosystem reflect the spectrum of behaviors, from specialists with narrow tolerances to generalists with broader tolerances. Importantly, even the least sensitive Tier 3 models are still constrained at least loosely by the ecosystem's climate and vegetation, and by the human footprint.

Resistance

Resistance refers to the degree to which a pixel impedes movement for species within the ecosystem. Each species' movement ecology is unique, and the resistance of the landscape for the myriad species within an ecosystem cannot be summarized in a single model. However, we can make generalizations about the boundaries within which species tied to an ecosystem are able to move. We developed our ecosystem resistance models based on the same 3 elements we used above to model habitat quality, with the assumption that the movement of species within the ecosystem follows routes that are within the ecosystem's climatic niche, in areas that broadly match the ecosystem's vegetation type, and avoid areas of high human footprint.

Resistance for each of the 3 elements was scaled from 0 to 1000 (most values were in the range of 0 to 20, but some urban environments and busy roads approached 1000). We calculated the final resistance model for Tier 1 within the ecosystem as the sum of resistance due to suboptimal climate, vegetation, and the human footprint, plus additional resistance due to water (r=100), areas of very high slope (r=100 at slope >= 60 degrees), and distance (r=1). For Tier 2 models, we calculated resistance as ½ of the Tier 1 models (retaining the minimum value of 1 to represent the effect of distance alone). Tier 3 model resistance was half of the Tier 2 resistance (minimum r=1).

Core Habitat

Core habitat is a local concentration of high-quality habitat that is internally well connected (i.e., resistance inside the core is low and there are no major movement barriers). We mapped core habitat for each ecosystem and each tier using a clustering approach. We trained the k-means clusterer, implemented in Google Earth Engine, on the ecosystem tier habitat and resistance models, sampled at 10,000 locations across the ecosystem, with the number of clusters set to 20. We then calculated the average habitat and resistance values within each cluster, and used a threshold of habitat and resistance in Table 24 to remove clusters that did not meet the criteria.

Table 24. Habitat and resistance thresholds for ecosystem tiers.

Ecosystem	Criteria	Tier 1	Tier 2	Tier 3
Montane Mesic and Montane Xeric Forest	Mean Habitat Threshold	0.75	0.5	0.25
	Mean Resistance Threshold	10	15	20
	Minimum Patch Area (ha)	1000	500	250
Temperate Forest	Mean Habitat Threshold	0.75	0.5	0.25
	Mean Resistance Threshold	10	15	20
	Minimum Patch Area (ha)	250	100	50
Shrubsteppe	Mean Habitat Threshold	0.75	0.5	0.35
	Mean Resistance Threshold	10	15	20
	Minimum Patch Area (ha)	1000	500	250

All clusters meeting the criteria for a given ecosystem and tier were combined into a single surface, and continuous patches of pixels meeting the criteria were converted to polygons, assigned a unique identifier. We calculated the area of each core patch and removed cores whose area was below the threshold provided in the table above. Finally, we calculated metrics for each core, including habitat weighted core area, mean habitat quality, mean resistance, and perimeter area ratio.

We summarized the core habitat across tiers for each ecosystem as the sum of the binary core area models per tier. The 3 tiers reflect an increasing tolerance for broader climatic and vegetation conditions within the ecosystem and an increasing tolerance to the human footprint. As such, Tier 1 cores were nested entirely within Tier 2 cores, which were nested entirely within Tier 3 cores. Summing the 3 tiers yielded a single surface scaled from 0 to 3 (0 = not core, 1 = Tier 3 core only, 2 = Tier 2 and 3 cores, and 3 = Tier 1, 2, and 3 cores).

Corridors

We used least cost corridor methods implemented in Google Earth Engine to map the least costly routes between all pairs of adjacent core habitat patches for the 3 tiers within each ecosystem. This involved 3 steps. In the first step, we calculated the adjacency of all cores based on the Euclidean distance to the nearest core. Next, we created ‘links’ (lines between the centroids of all adjacent cores) to represent potential connections to evaluate. We dropped links where the least costly route passed through another core before reaching the ‘target’ core, or when the total cost-distance of the least costly route exceeded 200km, or the Euclidean distance exceeded 100km. Finally, we mapped the least cost corridor for all links retained after the previous step. For each corridor, we calculated metrics of corridor quality, including total cost distance, total Euclidean distance, and the ratio of the cost distance to Euclidean distance.

Synthesizing and Scoring Tiered Ecosystem Data

Authors: Stephanie DeMay and Zaneta Kaszta, WDFW

The ecosystem core and corridor model tiers were nested such that the lower tiers included and expanded upon the higher tiers. We developed a map layer that was flattened to display the highest quality category for each location on the map. For example, all areas that were Tier 1 Cores were also Tier 2 and 3 Cores, but the flattened map displayed them as Tier 1 Cores because that was the highest value. We assigned connectivity values to each element of the ecosystem data using the following schema: Tier 1 Core (9), Tier 1 Corridor (7.5), Tier 2 Core (6), Tier 2 Corridor (4.5), Tier 3 Core (3), and Tier 3 Corridor (1.5). We extracted this polygon layer to the 1-mile grid by assigning the category with the most area within each cell.

We then applied a 20-mile radius circular moving window filter to calculate a normalized score of ecosystem connectivity, highlighting the importance of isolated local corridors, and rescaled the scores between 0 and 1.

Input layer 2: Westside Prairie Ecosystem

Authors: Jeff Azerrad and Zaneta Kaszta, WDFW

A map of westside prairie habitat in the south Puget Sound (SPS) region was developed to elevate the significance of core habitat and corridors that intersect with prairie. The map layer started by using a definition of westside prairie from WDFW's Priority Habitats and Species program (WDFW 2008). This definition includes a list of prairie-associated soil types, including a subset of soils associated with SPS prairies. These SPS prairie soils were selected as the foundation of the prairie map. To identify the location of these soils we used a soil survey layer derived from the Private Forest Land Grading System and subsequent soil surveys that is available on the Washington Spatial Data server (see [WA Soils | Washington State Geospatial Open Data Portal]). The SPS soil types were selected from this layer and then clipped to the boundary of the Southern Puget Prairie level IV ecoregion. To ensure our analysis focused on areas with a high probability of existing prairie habitat, rather than those impacted by development or forest encroachment, we used the Landfire Existing Vegetation Type layer to exclude open and undeveloped portions from the prairie soil layer.

To assess prairie intactness, we first calculated the proportion of prairie habitat within each 1-mile grid cell. We then integrated human impact by multiplying the prairie proportion layer with TerrAdapt's 2022 Human Footprint raster (see methods above), resampled to 1 mile and scaled from 0 (high impact) to 1 (low impact). The resulting layer quantifies prairie intactness, where values closer to zero represent more degraded areas and values closer to one represent more pristine prairie ecosystems.

Input layer 3. Permeability

Author: Andrew Shirk, TerrAdapt

The least-cost corridor models represented the most efficient routes between core areas given the resistance in the landscape. However, the distribution of corridors is highly sensitive to the location of the core areas, and habitat outside of cores is not represented as a source for movement in core-corridor models. As a complementary alternative method to map connectivity that does not depend on first mapping core areas, we ran a permeability model (Paul et al. 2023). This method assesses the degree to which a pixel is connected to its neighbors in a probabilistic way. We used the resistance model for each ecosystem as the input after rescaling it to range from 0 to 1 as resistance decreased from 150 to 1. Thus, pixels with the minimum resistance (1) were always included in the calculation. Pixels with a probability of less than 1 were compared to a random number per pixel. If the probability exceeded the random number, the pixel was retained, otherwise, it was dropped. Then, we calculated the patch size of all retained pixels that were contiguous. Finally, we summarized the patch sizes across 300 replicate runs, each with a different randomly generated probability surface. The result represents the spectrum of areas that are always connected (contiguous patches of the lowest resistance value) and areas that are increasingly less likely to be connected due to the resistance in the landscape.

To score this data, we resampled the 100-m resolution original data layer to the 1-mile grid and rescaled from 0 (low permeability) to 1 (high permeability).

Input layer 4. Network Importance (i.e., Dispersal Density)

Author: Andrew Shirk, TerrAdapt

One shortcoming of the core-corridor and permeability models is that they reveal the best routes through a landscape (between core areas, and locally to neighboring pixels, respectively), but they don't reflect the relative frequency at which those routes are likely to be used given the distribution of habitat and the quality of habitat across an ecosystem. Routes connecting two large core areas containing substantial high-quality habitat are much more likely to be used by dispersing individuals compared to routes that connect smaller and/or lower quality cores. The relative density is a function of the density of the population interacting with the patterns of resistance on the landscape and is a measure of centrality in the network of connected habitats (i.e., areas with the high dispersal densities are central within the population, connecting more of the population than less central areas). An understanding of relative dispersal density is valuable in that it enables prioritization of the most central parts of the network connecting the most high-quality habitat.

To address this gap, we calculated an index intended to reflect the relative dispersal density across the landscape for each ecosystem. The source of dispersal was the core areas and the dispersal density inside each core was the square root of the core area multiplied by the mean habitat quality of the core. Dispersal density decreased moving outwards from each core as a function of the square of cost distance, scaled from 1 to 0 as the cost distance from the core increased from 0 to the maximum cost distance of 100km. Summing these dispersal 'kernels' across all the cores yielded the final dispersal density. Areas with many large cores of high quality had very high dispersal density relative to areas with fewer, smaller cores of lower quality.

To score this data, we resampled the 100-m resolution original data layer to the 1-mile grid and rescaled from 0 (low importance) to 1 (high importance).

Input layers 5 and 6: Focal Species and Beaver Intrinsic Potential Data

Authors: Zaneta Kaszta, Jeff Azerrad, and Stephanie DeMay, WDFW

A comprehensive review by Species Matter Experts (SMEs) identified 22 focal species for which adequate spatial information on connectivity (population cores and/or movement corridors) was available (Appendix F: Focal species connectivity model summary table). Based on this review and an assessment of the models, we assigned weights to each species reflecting the quality of the spatial data. Subsequently, we processed these spatial data across all species to generate two layers representing core areas and corridors. The specific methodology employed is detailed below.

Cores and Corridors

We extracted to the 1-mile grid whether each cell contained modeled cores or corridors for each of the focal species. To avoid double-counting, each cell could be marked as a core or a corridor for a given species but not both. When a cell contained both core and corridor it was marked as core to reflect the higher quality core habitat found there. Using the weights in Appendix F: Focal species connectivity model summary table, we then calculated a weighted sum of the number of focal species with modeled cores in each cell and the number of focal species with modeled corridors in each cell. We rescaled these summed core and corridor layers to a 0 to 1 scale, assigned the summed core layer an extra weight of 1.5 and the summed corridor layer a weight of 1, and added the core and corridor layers to create a single data layer combining focal species cores and corridors.

To emphasize the significance of isolated local cores, we implemented a 20-mile radius circular moving window filter. For each 1-mile grid cell, this filter calculated a normalized score by dividing the cell's original score (i.e., weighted sum of species) by the highest score found within its surrounding 20-mile neighborhood. This process highlighted cells with high values relative to their immediate vicinity. We applied the same 20-mile radius circular moving window filter to calculate normalized score of the corridors, highlighting the importance of isolated local corridors.

Input layer 6: Beaver Intrinsic Potential

Author: Data created by Shawn Behling and incorporated into the analysis by Zaneta Kaszta, WDFW

To assess habitat suitability for the American beaver (*Castor canadensis*), we employed the Beaver Intrinsic Potential (BIP) layer (Dittbrenner et al. 2018). This spatial layer was generated by applying a generalized intrinsic potential model that leverages remotely sensed data on stream gradient, stream width, and valley width. The model aims to predict where beaver populations could establish given the presence of appropriate vegetation. Stream segments were assigned intrinsic potential scores ranging from 1 (low potential) to 3 (high potential). To incorporate potential habitat in the immediate vicinity of streams, a 300-m buffer was applied around each classified stream segment. Within this buffer, only areas with riparian, deciduous, or mixed deciduous/conifer canopy cover and low or moderate levels of development were retained.

Subsequently, using the classified BIP layer, we calculated a class-weighted proportion for each BIP class within every 1-mile grid cell. This involved determining the area occupied by each class within the cell and weighting it according to the class value. The resulting grid of values was then normalized by rescaling the scores to a 0-1 range.

Final Focal Species Layer

Given the significantly finer spatial scale of the final BIP layer relative to the focal species cores layer, we refrained from applying an additional local moving window scaling process to the BIP layer. Instead, we integrated the locally scaled focal species core areas layer with the final BIP layer. To reflect the higher overall importance of core areas compared to corridors, we applied a weight of 1.5 to the combined product.

Input layer 7: Species of Greatest Conservation Need

Author: Zaneta Kaszta, WDFW

We included mapped range data for 83 Species of Greatest Conservation Need (SGCN) identified in the 2015 State Wildlife Action Plan (SWAP) that had documented occurrences and associated spatial range data (WDFW 2015). To ensure data accuracy, we exclusively utilized observed species ranges, defined using WDFW occurrence data collected between 1978 and 2015 and delineated based on the USGS Hydrologic Unit Code (HUC) 12 watershed classification system. A HUC 12 watershed was considered part of a species' initial range if species occurrence was recorded within it. These preliminary ranges were subsequently reviewed and refined by WDFW species experts to represent the most current and certain depiction of recently occupied habitat. Detailed methodology regarding the development of SGCN ranges can be found in Appendix B of the 2015 SWAP.

Species were ranked based on their Federal and State protection status and inclusion in the WDFW Priority Habitats and Species (PHS) list. The highest rank of 1 was assigned to species with the strongest Federal and State protection, while the lowest rank of 0.3 was given to SGCN species not listed in PHS.

We created two versions of the SGCN layer. For the Transportation analysis, we used an SGCN layer that excluded flying birds because transportation crossing structures are primarily aimed at supporting terrestrial species. In the Landscape analysis, we retained all flying birds, but down weighted their scores to 0.75 due to the plan's focus on terrestrial connectivity. Similarly, a weight of 0.75 was applied to species already represented in our focal species cores and corridors layers. Additional weighting criteria based on protection status are detailed in Table 25.

Table 25. Weighting criteria for the Species of Greatest Conservation Need.

Protection status			Weighting
Federal	**State**	**PHS**	
Endangered	Endangered	Yes	1
Endangered	Threatened	Yes	1
Threatened	Endangered	Yes	1
None	Endangered	Yes	1
Threatened	Threatened	Yes	0.9
Threatened	Candidate	Yes	0.9
None	Threatened	Yes	0.9
None	Sensitive	Yes	0.8
None	Candidate	Yes	0.7
None	None	Yes	0.5

None	None	No	0.3

In the final SGCN layer the species ranges were added up according to their final ranking. The layer was then rescaled between 0-1 (1-representing pixels with the highest number of species with the highest ranking) and resampled to 1mile grid.

Input Layer 8: Climate Connectivity

Author: Data created by Parks et al. (2020) and incorporated into analysis by Zaneta Kaszta, WDFW.

To represent how landscape characteristics might facilitate or impede species movement under various climate change scenarios, we utilized a continent-wide model for North America published by Parks et al. (2020). This model employed a least-cost path approach to generate movement trajectories from each 5km pixel to its nearest future climate analog. The analysis prioritized paths avoiding dissimilar climates and areas with increasing human land-use intensity, as defined by the Human Modification Gradient (HMG). The resulting layer depicts the total number of these trajectories intersecting each 5km pixel. We clipped the climate connectivity layer to Washington state, resampled it to the1mi grid, and rescaled it between 0-1 (1 representing the highest climate connectivity).

Input Layer 9: Arid Lands Initiative and Biodiversity Areas and Corridors

Author: Stephanie DeMay, WDFW

This metric combined two existing spatial prioritizations in the Columbia Plateau. The first was the Arid Lands Initiative (ALI), which mapped priority Core Areas and Linkages using 500-acre hexagons (ALI 2014). The second was WDFW's Biodiversity Areas and Corridors (BACs) mapped for the Columbia Plateau at a 30-m resolution (WDFW 2023). Both of these prioritizations were heavily based on the same Columbia Plateau connectivity analysis (WHCWG 2012), though applied in different ways. Because of their similarities, we combined them into a single metric, where 1-mile grid cells that contained both ALI and BAC priorities received a score of 5, cells that contained only BAC priorities received a score of 4, cells that contained only ALI priorities received a score of 3, and those with neither ALI nor BAC priorities received no score. Scores were then rescaled between 0 and 1.

Input Layer 10: Washington Shrubsteppe Restoration and Resiliency Initiative

Author: Stephanie DeMay, WDFW

The Washington Shrubsteppe Restoration and Resiliency Initiative (WSRRI) created maps of spatial priorities for dry (xeric) ecosystems and wet (mesic) ecosystems in the Columbia Plateau ecoregion in Washington at a 100-m resolution. We combined these two ecosystem priorities into a single layer depicting the highest valued habitat category from either of the two ecosystem maps. Cores with the highest quality habitat received a score of 2. Growth Opportunity Areas (GOAs) were more degraded than cores but still had a significant amount of habitat that could become Core with restoration; these received a score of 1. Corridors received a score of 0.5. Scores were extracted to the 1-mile grid by assigning the highest WSRRI value within each cell and then rescaled between 0 and 1.

Appendix F: Focal species connectivity model summary table

Species	Source (year)	Type	Quality	Weight	Modified	Included	Reviewer	Details
American Beaver	Beaver Intrinsic Potential Model (2018)	Habitat Suitability	High	NA	Yes	Yes	Shawn Behling, WDFW	Beaver Intrinsic Potential (BIP) model with some modifications. Stream segments with a BIP score of 1 (low potential) to 3 (high potential) were buffered by 300 m and restricted to areas of low or moderate development or riparian, deciduous, or deciduous/conifer canopy.
American Marten	WWHCWG Statewide Model - American Marten Habitat Conservation Areas (2010)	Core	Low	NA	NA	No	Robert Long, Woodland Park Zoo	WWHCWG expert-based model developed using Gnarly Landscape Utilities (ArcGIS toolbox). The model is missing large areas of suitable habitat, particularly in western Washington and it overestimates high elevation habitat in the Olympic Peninsula.
	WWHCWG Statewide Model - American Marten Normalized Least-cost Corridor (2010)	Corridor	Low	NA	NA	No		WWHCWG expert-based model developed using Linkage Mapper
American Badger	WWHCWG Statewide Model - American Badger Core Areas (2010)	Core	Moderate	0.75	Yes	Yes	Lindsay Welfelt, WDFW	WWHCWG expert-based model developed using Gnarly Landscape Utilities (ArcGIS toolbox). Imperfect model but tracks well good habitat for badger. Reviewer identified a few areas where badgers occur that WAHCAP team added to the core habitat map. This included a large area in the Okanogan Highlands where data from occupancy models informed by camera-trapping

								arrays (King et al. 2020) was used to add a new core to the map used in the WAHCAP synthesis.
	WWHCWG Statewide Model - American Badger Normalized Least-cost Corridors (2010)	Corridor	Moderate	0.75	No	Yes		WWHCWG expert-based model developed using Linkage Mapper
Black Bear	WWHCWG Statewide Model - American Black Bear Normalized Least-cost Corridors (2010)	Core	Moderate	0.75	Yes	Yes	Lindsay Welfelt, WDFW; Zach Robinson, Muckleshoot Tribe	WWHCWG expert-based model developed using Gnarly Landscape Utilities (ArcGIS toolbox). Imperfect model but tracked generally well with our best understanding of good black bear habitat. Both reviewers added important cores that were missing from the WWHCWG statewide black bear model. These were added to the core area map used in the WAHCAP synthesis.
	WWHCWG Statewide Model - American Black Bear Normalized Least-cost Corridors (2010)	Corridor	Moderate	0.75	No	Yes		Corridors were modelled using Linkage Mapper

Black-tailed Jackrabbit	WWHCWG Columbia Plateau Model - Black-tailed Jackrabbit Habitat Concentration Areas (2012)	Core	Low	0.5	No	Yes	Gerry Hayes, WDFW	WWHCWG expert-based model developed using Gnarly Landscape Utilities (ArcGIS toolbox). The model was compared to range maps in Washington's State Wildlife Action Plan to confirm it met at least the minimum threshold for use in WAHCAP prioritization.
	WWHCWG Columbia Plateau Model - Black-tailed Jackrabbit Least-cost Corridors (2012)	Corridor	Low	0.5	No	Yes		Corridors were modelled using Linkage Mapper.
Bighorn Sheep	WWHCWG Statewide Model - **Error! Hyperlink reference not valid.**	Core	High	1	Yes	Yes	Will Moore, Emily Jeffries, Jeff Heinlen, WDFW	WWHCWG expert-based model developed using Gnarly Landscape Utilities (ArcGIS toolbox). Reviewers added several core areas for herds in Okanogan and Ferry counties and refined the boundaries of cores along Lake Chelan in Chelan County by supplying maps with the actual herd locations. SME deleted a core in Yakima County that was no longer viable.
Bighorn Sheep	WWHCWG Statewide Model - **Error! Hyperlink reference not valid.**	Corridor	High	1	Yes	Yes		Corridors were modelled using Linkage Mappe. A corridor to and from recently formed herds in Okanogan County was added. Corridors that were too distant for mountain goats to feasibly travel between cores were removed. Corridors with known risk of disease transmission between herds were also removed.

Canada Lynx	Combined WAHCAP - WWHCWG Canada Lynx Core Habitat model (2024)	Core	High	1	Yes	Yes	Lindsay Welfelt, WDFW	The model was developed by WAHCAP using habitat suitability (HS) layer (Andrew Shirk) and the 2022 human footprint model (Terradapt). The HS layer was derived using lynx locational data for the Cascades of Washington and British Columbia. Core areas were defined by running cumulative resistant kernel analyses in UNICOR (REF). Reviewer assessed this model as high quality and superior to the older WWHCWG expert-based model.
	WWHCWG Statewide Model - **Error! Hyperlink reference not valid.**	Corridor	Moderate	1	No	Yes		WWHCWG expert-based model developed using Linkage Mapper
Cougar	WAHCAP Cougar Core Habitat model (2024)	Core	High	1	Yes	Yes	Rich Beausoleil, WDFW	WAHCAP team developed a core model for cougar using the O'Malley et al. (2024) HS model. The HS model was derived from a random forest model using GPS data from 476 individuals across 20 study sites in the western USA and Canada and remotely sensed landscape data. We ran cumulative resistant kernel analysis to define core areas and factorial least cost paths to delineate movement corridors. Compared to the WWHCWG model (2010), this one is based on actual species observations as well as more up-to-date environmental data. We
	WAHCAP Cougar Linkages Model (2024)	Corridor		1	Yes	Yes		

								refined the WAHCAP cougar core habitat model by adjusting the minimum habitat value per reviewer's specifications and we removed corridors which did not link any core areas.
Elk	WWHCWG Statewide Model - **Error! Hyperlink reference not valid.**	Core	High	1	Yes	Yes	Brendan Oates, Kyle Garrison, Shelly Ament, Bryan Murphie, and Ben Turnock, WDFW ; Zach Robinson, Muckleshoot Tribe	WWHCWG expert-based model developed using Gnarly Landscape Utilities (ArcGIS toolbox). Reviewers assessed the model as good but pointed out modifications that were made in southwest, southeast, and central Washington and the Olympic Peninsula to improve map accuracy.
	WWHCWG Statewide Model - **Error! Hyperlink reference not valid.**	Corridor	High	1	No	Yes		Corridors were modelled using Linkage Mapper
Greater Sage-grouse	WSRRI Sage-Grouse Priorities (2024)	Core	High	1	No	Yes	Mike Atamian, WDFW	This data come from the WSRRI initiative. The HS model based on sage-grouse observation was developed using MAXENT algorithm and used in Linkage Mapper to define core areas and corridors. Two types of spatial priority areas were defined: cores and growth opportunity.

Greater Sage-grouse	WSRRI Sage-Grouse Priorities (2024)	Corridor	High	1	No	Yes		
Grizzly Bear	Modified Grizzly Bear Recovery Area	Core	Moderate	0.75	Yes	Yes	Annmarie Prince, Ben Turnock, Megan Turnock, WDFW	WAHCAP team developed a refined core and corridor model for grizzly bear using cumulative resistant kernels and factorial least-cost paths. These models were using HS based on empirical data (Andrew Shirk) and Human Footprint (TerrAdapt, 2022). Reviewers concluded that the WAHCAP derived map of cores were not consistently identifying species habitat. They suggested using a buffered grizzly bear recovery area layer to represent core habitat until something better is available.
	WAHCAP Grizzly Bear Linkages (2024)	Corridor	Low	NA	No	No		
Least Chipmunk	WWHCWG Columbia Plateau Model - Habitat Concentration Areas (2012)	Core	Low	0.5	No	Yes	No reviewer	WWHCWG expert-based model developed using Linkage Mapper. The model was compared to range maps in Washington's State Wildlife Action Plan to confirm it met at least the minimum threshold for use in WAHCAP prioritization.
	WWHCWG Columbia Plateau Model - Normalized Least-cost Corridors (2012)	Corridor	Low	0.5	No	Yes		

Mountain Beaver	WWHCWG Cascades to Coast Model - Mountain Beaver Habitat Concentration Areas (2012)	Core	Low	NA		No	WAHCAP Core Team	WWHCWG expert-based model developed using Gnarly Landscape Utilities (ArcGIS toolbox) and Linkage Mapper. Excluded because data were of poor quality.
	WWHCWG Cascades to Coast Model - Mountain Beaver Least-cost Corridors (2012)	Corridor	Low	NA		No		
Mountain Goat	WWHCWG Statewide Model - Mountain Goat Core Areas (2010)	Core	High	1	Yes	Yes	Will Moore, Emily Jeffries, Jeff Heinlen, Erin Wampole, WDFW Zach Robinson, Muckleshoot Tribe	WWHCWG expert-based model developed using Gnarly Landscape Utilities. Reviewers refined core areas around Lake Chelan using survey unit boundaries defined by mountain goat observational data. New cores were also added using herd survey units for herds observed on the boundary between Yakima and Pierce counties as well as for herds in Kittitas County.
	WWHCWG Statewide Model - Normalized Least-cost Corridors (2010)	Corridor	Low	NA		No		Corridor model developed using Linkage Mapper reviewed as highly flawed - represented as straight lines between cores.
Mule Deer	WDFW Columbia Plateau Mule deer empirical habitats (2012)	Cores	High	1	No	Yes	Samantha Budnick, WDFW	The initial review of WWHCWG core and corridor (Gnarly Landscape Utilities and Linkage Mapper) models concluded that the models are flawed and should not be used. The reviewer provided an empirical corridor model to use in place of the WWHCWG model. Using these data, cores

	WDFW Columbia Plateau Mule deer empirical corridors (2012)	Corridors	High	1	No	Yes		were generated by performing a union of the data in GIS of summer, winter, and stopover habitats for multiple herds. Corridors were generated by buffering linear routes via a time series of empirical data points for four herds.
Pacific Fisher	WAHCAP Fisher Model (2024)	Core	High	1	Yes	Yes	Jeff Lewis, WDFW Jennifer Sevigny, Stillaguamish Tribe	The model was developed by WAHCAP using habitat suitability (HS) layer (Andrew Shirk) and the 2022 human footprint model (Terradapt). The HS layer was derived from species observations in Cascades and Olympics supplied by WDFW and other agencies/partners, plus sparse locations in interior British Columbia. Based Cumulative resistant kernel approach was applied to define core areas. The reviewer noted that the model, although good, underrepresented habitat in eastern Washington. Reviewer asked not to use cores modelled north of Interstate 90 due to lack of empirical data.
	WWHCWG Cascades to Coast Model - Fisher Least-cost Corridors (2022)	Corridor	High	1		Yes		WWHCWG corridor model based on Linkage Mapper

Sharp-tailed Grouse	WWHCWG Columbia Plateau Model - Sharp-tailed Grouse Habitat Concentration Areas (2012)	Core	Moderate	0.75	No	Yes	Mike Atamian, WDFW	WWHCWG expert-based model developed using Gnarly Landscape Utilities and Linkage Mapper. Reviewer concluded WWHCWG model is outdated but that it represents the best existing source for this species. Reviewer pointed that although the WWHCWG model does not include potential sharp-tailed grouse core habitat, the WSRRI "Xeric Habitats" corridors model has some potential to fill in some of the gaps in the WWHCWG model.
	WWHCWG Columbia Plateau Model - Sharp-tailed Grouse Normalized Least-cost Corridors (2012)	Corridor	Moderate	0.75	No	Yes		
Tiger Salamander	WWHCWG Columbia Plateau Model - Tiger Salamander Habitat Concentration Areas (2012)	Core	Low	0.75	No	Yes	Lisa Hallock, WDFW	WWHCWG expert-based model developed using Linkage Mapper. WWHCWG model was compared to range maps in Washington's State Wildlife Action Plan to confirm it met at least the minimum threshold for use in WAHCAP prioritization.
	WWHCWG Columbia Plateau Model - Tiger Salamander Normalized Least-cost Corridors (2012)	Corridor	Low	0.75	No	Yes		Corridors were modelled using Linkage Mapper
Townsend's Ground Squirrel	WWHCWG Columbia Plateau Model - Townsend's Ground Squirrel Habitat Concentration Areas (2012)	Core	Low	0.75	No	Yes	Gerry Hayes, WDFW	WWHCWG expert-based model developed using Gnarly Landscape Utilities and Linkage Mapper. WWHCWG model was compared to range maps in Washington's State Wildlife Action Plan to confirm it met at least the minimum threshold for use in WAHCAP prioritization.

	WWHCWG Columbia Plateau Model - Townsend's Ground Squirrel Normalized Least Cost Corridor (2012)	Corridor	Low	0.75	No	Yes		
Washington Ground Squirrel	WWHCWG Columbia Plateau Model - Washington Ground Squirrel Habitat Concentration Areas (2012)	Core	Low	0.75	No	Yes	Gerry Hayes, WDFW	WWHCWG expert-based model developed using Gnarly Landscape Utilities and Linkage Mapper. WWHCWG model was compared to range maps in Washington's State Wildlife Action Plan to confirm it met at least the minimum threshold for use in WAHCAP prioritization.
	WWHCWG Columbia Plateau Model - Washington Ground Squirrel Normalized Least Cost Corridors (2012)	Corridor	Low	0.75	No	Yes		
Western Gray Squirrel	WWHCWG Cascades to Coast Model - Western Gray Squirrel Habitat Concentration Areas (2022)	Core	High	1	No	Yes	Jeff Azerrad, WDFW	WWHCWG expert-based model developed using Gnarly Landscape Utilities and Linkage Mapper. Jeff Azerrad led the development of this recently produced model. During that process, the model was reviewed by WDFW species subject matter experts, Matt Vander Haegen and Mary Linders, who verified its accuracy.
	WWHCWG Cascades to Coast Model - Western Gray Squirrel Least-Cost Corridors (2022)	Corridor	High	1	No	Yes		

Western Rattlesnake	WWHCWG Columbia Plateau Model - Western Rattlesnake Habitat Concentration Areas (2012)	Core	Moderate	0.5	No	Yes	Lisa Hallock, WDFW	WWHCWG expert-based model developed using Gnarly Landscape Utilities and Linkage Mapper. Reviewer identified that the model misses some areas with known western rattlesnake populations.
	WWHCWG Columbia Plateau Model - Western Rattlesnake Normalized Least Cost Corridor (2012)	Corridor	Moderate	0.5	No	Yes		
Western Toad	WWHCWG Statewide Model - Western Toad Habitat Concentration Areas (2010)	Core	Low	NA	No	No	Reed Ojala-Barbour, WDFW	WWHCWG expert-based model developed using Gnarly Landscape Utilities and Linkage Mapper. The model misses some important areas e.g. the Willapa Hills and misidentifies cores (e.g. Lake Washington).
	WWHCWG Statewide Model - Western Toad Normalized Least-cost Corridors (2010)	Corridor	Low	NA	No	No		
White-tailed Jackrabbit	WWHCWG Columbia Plateau Model - White-tailed Jackrabbit Habitat Concentration Areas (2012)	Core	Low	0.5	No	Yes	Gerry Hayes, WDFW	WWHCWG expert-based model developed using Gnarly Landscape Utilities and Linkage Mapper. The model was compared to range maps in Washington's State Wildlife Action Plan to confirm it met at least the minimum threshold for use in WAHCAP prioritization.

	WWHCWG Columbia Plateau Model - White-tailed Jackrabbit Normalized Least Cost Corridor (2012)	Corridor	Low	0.5	No	Yes		
Wolverine	WAHCAP-WWHCWG Model - Wolverine Core Habitat (2024)	Core	High	1	Yes	Yes	Jeff Lewis, WDFW	The model was developed by WAHCAP using habitat suitability (HS) layer (Andrew Shirk) and the 2022 human footprint model (TerrAdapt). The HS layer was derived from all locations in the Washington Cascades, mostly from USFS. The model used cumulative resistant kernel approach to derive core areas. Reviewer suggested to union this model with core areas generated by the WWHCWG (expert-based Linkage Mapper model).
	WWHCWG Statewide Model - Wolverine Normalized Least-cost Corridor (2010)	Corridor	High	1	No	Yes		WWHCWG expert-based least-cost corridor model developed using Linkage Mapper.

Appendix G: Connectivity hot spot and conversion pressure methodology

Author: Zaneta Kaszta, WDFW

Connectivity value hot spots

We used the landscape connectivity surface to identify areas with high connectivity values that were aggregated into homogenous patches. To achieve this, we applied a cost-kernel approach to a set of source points which were selected probabilistically proportional to the landscape connectivity surface values. The kernel analysis penalized spread as a nonlinear function of connectivity value, such that the kernel spreads farther through areas of continuously high connectivity value and spreads shorter distances in areas of low connectivity value. This produced a kernel density surface showing aggregated areas of high connectivity value.

To compute kernel density at each source location we applied a two-step transformation to the landscape connectivity surface. First, connectivity values were linearly inverted. Second, an exponential transformation was applied to these inverted values, with the function's steepness calibrated to increase rapidly around one-quarter of the original maximum connectivity value, as follows:

$$\textit{Transformed value} = \exp\,(\textit{original value} \times 0.25)$$

This transformation aimed to emphasize areas of higher original connectivity in the subsequent kernel density calculation and bandwidth determination.

The resulting transformed surface was also used to establish source locations for kernel placement. This process involved two stages: first, the transformed connectivity surface was rescaled to a 0-to-1 range. Second, a uniform random raster (values 0-1) with identical spatial properties was generated. This random raster was then subtracted from the rescaled connectivity surface. Only locations exhibiting a positive difference (i.e., where the rescaled connectivity value exceeded the corresponding random value) were selected as source locations for kernel placement.

For the kernel density analyses, the transformed connectivity surface was further linearly inverted and rescaled to a range of 1 to 10, assigning lower values to areas of high original connectivity. This inverse relationship generated a 'cost surface', where higher original connectivity corresponded to lower cost, thus penalizing the kernel's spread into areas of lower connectivity based on a predefined cumulative cost. Specifically, the kernel expands until this cumulative score is reached; thus, source locations in areas of high connectivity will result in wider kernel shapes. In this analysis, we set the cost-weighted distance of kernel spread at 15,840 cost-weighted distance units. This cost-weighted distance is equivalent to a spatial spread of 3 miles in areas of the landscape with the highest connectivity values, where the lower cost allows for a greater spatial spread for a given cost-weighted distance. To calculate kernel density, we utilized UNICOR software (Landguth et al. 2012).

Residential and commercial development data analysis

To identify areas with concentrated extents of high connectivity value which are also facing significant threat from potential housing and residential development, we applied kernel density analyses following the methodology detailed in the preceding section by adjusting the cost surface to account for the development.

To specifically quantify areas under high development pressure, we employed the Mann-Kendall Index (ref). This non-parametric test was computed to detect statistically significant monotonic trends in TerrAdapt's 30-year Human Footprint time series data (see above). For each landscape unit, the Mann-Kendall Index yielded a value where positive indices indicated an increasing trend in development pressure. We rescaled the positive index values to a range of 0 to 1, with 1 representing the highest development pressure.

This rescaled development pressure layer was subsequently integrated with areas of relatively high connectivity. To achieve this, we selected portions of the original connectivity surface with values exceeding the 30th percentile (connectivity value > 8) and rescaling it to a 0-to-1 range, where 1 denoted the highest connectivity within this subset.

Finally, we multiplied the rescaled development pressure layer by the rescaled high-connectivity layer. The resulting surface, ranging from 0 to 1, represented the spatial congruence of high development threat and high connectivity, signifying areas of heightened vulnerability.

We used the multiplication layer as the base to generate source locations and 'cost surface' to fit and compute kernel density. We applied the same transformation and methodology as detailed in the section above, setting the kernel cost-weighted distance at 79,200 – an equivalent of 15 mi in uniform landscape with the lowest cost defined by highest development and connectivity values

Solar suitability data analysis

To identify focal connectivity areas with a high threat of solar development we used The Solar Development Suitability Model for Columbia Plateau created by a mapping group for the Least-Conflict Solar Project managed by Washington State University Energy Program (Washington State Energy Program, 2023). The model was built using Environmental Evaluation Modeling System (EEMS) developed by the Conservation Biology Institute (CBI).

EEMS is a flexible, data-driven framework that uses fuzzy logic to integrate various spatial data layers and assess complex environmental and planning questions. It allows for the combination of different types of data (e.g., ecological, infrastructure, land use) to produce a suitability map. The logic of The Solar Development Suitability Model aimed at depicting relative physical suitability for utility scale passive solar development. At a high level of this hierarchical model, high development suitability was defined by characteristics such as terrain (slope and aspect) and soil conditions, high proximity to existing road and transmission infrastructure, and to a lesser degree potential hazards (i.e., wildfire and earthquakes).

The values of The Solar Development Suitability Model ranged from -1 (highly unsuitable) to 1 (highly suitable). We extracted only the positive values by setting all negative values to 0. We then multiplied this layer by the rescaled (0-1) connectivity value surface, representing areas with relatively high connectivity (portions of the original connectivity surface with values exceeding the 30th percentile). The resulting layer assigned higher values to areas of high connectivity threatened by solar development.

We then used this final multiplication layer to compute a kernel density surface, following the **methodology** described in previous sections. Similarly to the residential development analyses, we applied a kernel cost-weighted distance of 79,200.

Integrated habitat conversion surface

The three final density surfaces described in the previous sections were reclassified, cleaned from isolated pixels, and finally combined into one integrated habitat conversion surface. A detailed explanation of the process is provided below.

First, we reclassified the three surfaces to assign a unique ID to each cluster (hot spot). The focal areas with high connectivity values were reclassified based on their median to limit their extents to only the highest kernel density values. Therefore, all values higher than 1.5 were reclassified to 1 with everything else assigned to 0. In case of focal connectivity areas threatened by residential and commercial development we assigned all the values higher than 0.01 value 10 and everything else value 0. We applied the same threshold for focal connectivity areas threatened by solar development, assigning pixels with value higher than 0.01 value 100. Second, to maintain only larger aggregations of three or more units (≥9 mi^2 or 2.3 ha) we filtered out all the isolated aggregations of two or one pixels with value higher than 0. We then added all three rasters together. This resulted in a surface which gave unique ID to pixels with any possible combinations of the three considered factors of the prioritization (

Table 26).

Table 26. Combinations of high connectivity and threats and their associated values.

Combined value	Reclassified final value	Description
1	1	High connectivity and no threat
10	10	High connectivity threatened by residential and commercial development
11	10	High connectivity threatened by residential development
100	100	High connectivity threatened by solar development
101	100	High connectivity threatened by solar development
111	110	High connectivity threatened by BOTH residential and solar development