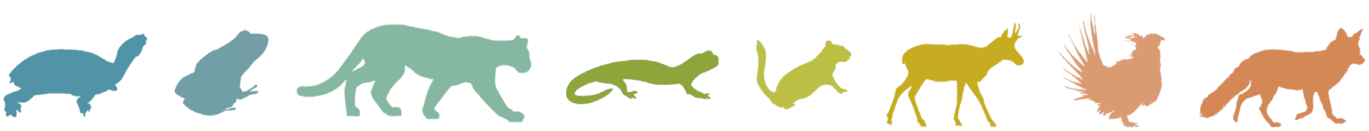
Oregon Connectivity Assessment and Mapping Project



Executive Summary

Oregon Connectivity Assessment and Mapping Project (OCAMP)

Executive Summary

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July 2023

ACKNOWLEDGMENTS

During the three-year effort to complete OCAMP, there was substantial and invaluable participation from more than 100 people representing over 75 organizations across Oregon and beyond. The execution of OCAMP and the development of Priority Wildlife Connectivity Areas has greatly benefited from the contributions of the Species Expert, Stakeholders, and Practitioners Working Group members.

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OCAMP has been supported by:
United States Fish and Wildlife Service:
Science Applications
US Sport Fish and Wildlife Restoration Act
State Wildlife Grants Program

Oregon Department of Fish and Wildlife

Oregon Department of Transportation

Suggested Citation: Oregon Connectivity Assessment and Mapping Project: Executive Summary. 2023. Oregon Department of Fish and Wildlife, Salem, OR. 20p.

Table of Contents

Introduction

Wildlife rely on the ability to move across the landscape to fulfill their daily and seasonal requirements to access water, food, shelter, and opportunities to reproduce. Human changes to the landscape often restrict the ability of wildlife to move by creating barriers, causing impacts to critical migration stopover sites, increasing habitat fragmentation, and inducing changes in wildlife behavior. Connected habitats aid wildlife in responding to shifting landscape conditions, allowing animals to safely move to seek new habitat following disturbances like human development, wildfire, drought, severe weather, the spread of invasive species, and changing climate. Oregon has over 1,000 wildlife species, with 294 identified as species of greatest conservation need (i.e., Strategy Species), which have small or declining populations, are at-risk, and/or are of management concern. Mapping and maintaining critical areas on the landscape that facilitate wildlife movement will help sustain population connectivity and biodiversity and aid in the conservation of at-risk species.

"Barriers to Animal Movement" is one of seven Key Conservation Issues outlined within Oregon's State Wildlife Action Plan, the Oregon Conservation Strategy (Strategy), which is the overarching state strategy for conserving Oregon's fish and wildlife species. The importance of species and habitat connectivity is identified under Goal 2 of the Barriers to Animal Movement Key Conservation Issue: 'Provide connectivity of habitat for the broad array of wildlife species throughout Oregon.' The need for developing connectivity maps is identified under Action 2.2: 'Continue to collect terrestrial wildlife movement data and refine maps and models to better identify and prioritize wildlife movement corridors.'

Providing and conserving habitat connectivity is a key management strategy to preserve species and ecosystem processes under a changing climate. Warming temperatures are affecting Oregon's fish and wildlife and their habitats, including species of greatest conservation need. Many species are shifting their ranges northward and higher in elevation and require connected landscapes to find suitable habitat and tolerable temperatures in new areas. Improving the connectivity of natural landscapes to better link fish and wildlife populations and allow for range shifts is also an integral component of the Oregon Conservation Strategy, identified as Goal 2, Action 2.1 for the Climate Change Key Conservation Issue.

Oregon faces mounting pressure from residential, commercial, and exurban development, agriculture, transportation, energy development, and resource extraction that fragment the landscape and have compromised the integrity and connectivity of wildlife populations and their habitats.

OCAMP

The Strategy identifies a need for a statewide analysis of existing wildlife habitat connectivity. In the past, efforts to map wildlife connectivity in Oregon were based on expert opinion that was insufficient to support decision-making regarding species' mobility and habitat connectivity needs. Recent improvements in the resolution of geospatial data, along with new and more robust statistical modeling techniques, have made fine-resolution, landscape-scale habitat connectivity modeling feasible.

Following a revision of the Strategy in 2016, a diverse group of stakeholders convened the Oregon Habitat Connectivity Consortium (OHCC), a group formed to promote functional natural landscape connectivity and to mitigate barriers to wildlife movement at multiple scales throughout Oregon and the surrounding region. Members of the OHCC included the Oregon Department of Fish and Wildlife (ODFW), Portland State University, Oregon Department of Transportation, US Fish and Wildlife Service, US Forest Service, Bureau of Land Management, The Nature Conservancy, Oregon Wildlife Foundation, Defenders of Wildlife, Burns Paiute Tribe, and Samara Group. The OHCC, led by ODFW, developed an implementation plan for how best to assess and map habitat connectivity for wildlife throughout Oregon, based on current best practices in landscape scale connectivity modeling.

The implementation plan guided the execution of a multi-year, collaborative effort to map existing habitat connectivity in the state, called the Oregon Connectivity Assessment and Mapping Project (OCAMP). Work on OCAMP was initiated in 2019 and completed in 2022. The project was executed by a partnership between ODFW, Portland State University, and Samara Group, and benefitted from input from experts in other state and federal agencies, as well as universities, Tribes, non-profits, consulting groups, and other NGOs.

The primary product of OCAMP is an interconnected network of Priority Wildlife Connectivity Areas that highlight the parts of the landscape with the highest overall value for facilitating wildlife movement in Oregon. Priority Wildlife Connectivity Areas include both areas of good quality habitat in intact, relatively undisturbed parts of the landscape, as well as the best remaining marginal habitat to help wildlife navigate through developed or degraded areas.

This document includes a summary of project methods and provides guidance for applying Priority Wildlife Connectivity Areas to conservation planning and on-the-ground enhancement, restoration, and protection of wildlife habitat. For those seeking a more detailed understanding of the development and interpretation of OCAMP products, including the rationale behind the selected methodologies, the statistical approaches used in validating model output, and project limitations, we recommend reading the OCAMP Technical Report.

Methods

The Oregon Connectivity Assessment and Mapping Project included seven primary steps, from selection of project species through to the development of the final Priority Wildlife Connectivity Areas.

The development of Priority Wildlife Connectivity Areas was a multi-year, cooperative effort among a wide diversity of project partners and stakeholders. The Oregon Department of Fish and Wildlife led this effort in close collaboration with Portland State University and Samara Group, but many of the steps taken to complete OCAMP and identify Priority Wildlife Connectivity Areas involved significant partner engagement. More than 100 individuals representing 77 different state and federal agencies, Tribes, universities, and NGOs assisted with species selection, expert review of draft habitat models for each species, and review of draft Priority Wildlife Connectivity Areas. Many individuals also contributed species occurrence data used in statistical validation of habitat models.

Surrogate species selection

Native species in Oregon were evaluated to assess suitability for connectivity modeling. Candidates were evaluated based on understanding of each species' habitat requirements and availability of data to support development and validation of habitat models. After extensive input and review from staff and partners, 54 native wildlife species were selected for connectivity mapping in Oregon. Each species selected for the project acted as a surrogate, or representative, for a broader suite of species based on habitat associations and requirements, movement capabilities and limitations, and responses to different types of stressors that may act as a barrier to animal movement, such as roadways, land use, and fencing. As a result, the cumulative needs of the selected 54 species are intended to represent the highest value connections for all of Oregon's wildlife.

The surrogate species we selected represent not only diverse habitat types, but also a diversity of habitat structural characteristics, life histories, and mobility types (Table 1). The 54 project species include 23 mammals, 16 birds, eight amphibians, four reptiles, and three invertebrate species. They include large-bodied, highly mobile animals that can utilize a diversity of habitat types, such as Rocky Mountain elk (*Cervus canadensis nelsoni*), mule deer (*Odocoileus hemionus hemionus*), and cougar (*Puma concolor*), as well as smaller species such as black-tailed jackrabbit (*Lepus californicus*), Pacific marten (*Martes caurina*), American beaver (*Castor canadensis*), pileated woodpecker (*Dryocopus pileatus*), and western toad (*Anaxyrus boreas*). They also include species with very limited mobility that have more specific habitat needs, such as Oregon slender salamander (*Batrachoseps wrighti*), coastal tailed frog (*Ascaphus truei*), and Fender's blue butterfly (*Icaricia icarioides fenderi*).

The diverse wildlife species selected as surrogates for OCAMP

Table 1: Selected species and habitat representations by ecoregion

Ecoregion	Species Common Name	Selected to Represent
Blue Mountains	Bighorn Sheep	Dwarf Shrub-steppe: Alpine meadows and rocky slopes
	Black-tailed Jackrabbit	Shrub-steppe: sagebrush, shadscale, greasewood, chaparral thickets and forest edges
	Lewis's Woodpecker	Westside Oak and Dry Douglas-fir Forest and Woodlands: High density of snags
	Long-toed Salamander	Herbaceous Wetlands: Dense cover such as leaf litter/down wood
	Mountain Goat	Alpine Grasslands and Shrublands/Subalpine Parkland
	Cougar	Habitat Generalist: Focal species
	Red-naped Sapsucker	Upland Aspen Forest
	Rocky Mountain Elk	Habitat Generalist: Focal species
	Western Rattlesnake	Westside Lowlands Conifer-Hardwood Forest: South-facing rocky outcroppings
Cascades	American Pika	Alpine Grasslands and Shrublands/Subalpine Parkland: Associated with talus slopes
	Cascades Frog	Alpine Grasslands and Shrublands/Subalpine Parkland: Permanent lentic waterbodies
	Coastal Tailed Frog	Conifer hardwood forests: Headwater streams
	Great Gray Owl	Eastside (Interior) Mixed Conifer Forest/Ponderosa Pine Forest and Woodlands: Montane meadows
	Hoary Bat	Westside Lowlands Conifer-Hardwood Forest: Mature stands
	Pacific Marten	Montane Mixed Conifer Forest: Mid/late seral, multi-layered canopy
	Mule Deer	Habitat Generalist: Focal species
	Oregon Slender Salamander	Westside Riparian Wetlands, Late Seral Stage Douglas-fir Forests
	Pileated Woodpecker	Mixed Conifer Woodlands: Snags in valley bottoms
	Sierra Nevada Red Fox	Alpine Grasslands and Shrublands/Subalpine Parkland
	Western Bumblebee	Mixed Conifer Woodlands: Floral resources
	Western Toad	Montane Coniferous Wetlands
Coast Range	American Beaver	Open Water/Riparian & Herbaceous Wetlands
	Northern Flying Squirrel	Conifer Hardwood Forests: Mid/late seral, interconnected conifer canopies
	Northern Red-legged Frog	Conifer Hardwood Forests: Mid/late seral, aquatic-terrestrial linkage/pond associated

	Pacific-slope Flycatcher	Conifer Hardwood Forests: Old growth/mature stands, multiple canopy layers
	Snowy Plover	Coastal Dunes & Desert Playa and Salt Scrub Shrublands: associated with dry salt flats and salt-evaporated waterbodies
	Townsend's Chipmunk	Conifer Hardwood Forests: Early seral stage and clearings
	Wrentit	Dense shrub layers, also associated with oak woodlands
Columbia Plateau	Burrowing Owl	Shrub-Steppe: Open, treeless areas with low sparse vegetation
	Ord's Kangaroo Rat	Shrub-steppe: Associated with open areas and sandy substrates
	Vesper Sparrow	Shrub-steppe: Associated with open areas and short, sparse grass and scattered shrubs
Klamath Mountains	Black-tailed Deer	Habitat Generalist: Focal species
	Pacific Fisher	Montane Mixed Conifer Forest, Eastside (Interior) Mixed Conifer Forest, Westside Riparian-Wetlands, and Westside Lowlands Conifer-Hardwood Forest
	Foothill Yellow-legged Frog	Southwest Oregon Mixed Conifer-Hardwood Forest: Streams, riparian edges, & gravel bars
	Hermit Thrush	Southwest Oregon Mixed Conifer-Hardwood Forest: Dense shrub layers
	Little Brown Myotis	Ponderosa Pine Forest and Woodlands: Forest areas associated with pond, lakes or streams
	Northern Alligator Lizard	Conifer hardwood forests: Meadow edges and riparian zones
	Roosevelt Elk	Habitat Generalist
	Western Pond Turtle	Open Water: Lakes, rivers and streams
Northern Basin and Range	Columbia Spotted Frog	Open Water/Riparian & Herbaceous Wetlands
	Ferruginous Hawk	Shrub-Steppe/Dwarf Shrub-Steppe: Cliffs, outcrops and tree groves
	Lazuli Bunting	Eastside Riparian Wetlands: Open woodlands with dense shrub cover
	Long-nosed Leopard Lizard	Desert Playa and Salt Scrub Shrublands: Scattered low plants with sandy/gravel substrates
	Morrison's Bumblebee	Shrub-steppe: flowering plants
	Porcupine	Upland Aspen Forest
	Pronghorn	Shrub-Steppe: Open, expansive terrain
	Pygmy Rabbit	Shrub-Steppe: Areas with tall, dense shrub cover
	Greater Sage-grouse	Shrub-Steppe: Focal species
	Western Meadowlark	Eastside Grasslands: Associated with open grasslands, prairies, and meadows
Willamette Valley	Bushy-tailed Woodrat	Montane Mixed Conifer Forest: Early/mid seral, open and/or rocky habitats

	Fender's Blue Butterfly	Grasslands/Prairie: Early seral
	Purple Martin	Westside Lowlands Conifer-Hardwood Forest: Early seral, associated with snags
	Western Gray Squirrel	Westside Lowlands Conifer-Hardwood/ Dry Doug Fir-Oak: Mid/late seral
	White-breasted Nuthatch	Oak woodlands: Mid/late seral

Habitat permeability modeling

For each of our 54 surrogate species, we reviewed all of the available research on the species' habitat requirements, preferences, and tolerance for moving through unsuitable habitats. In particular, we looked for any information on features that are known to be a barrier to movement for each species, such as roadways, developed areas, or certain types of landcover. For all species, we prioritized research that was published within the last ten years and research that was done in Oregon. Once we had compiled information on all of the salient habitat needs, tolerances, and barriers for each species, we used this information to develop species-specific Habitat Permeability Models (HPMs).

Habitat Permeability Models indicate how easy or difficult it is for a given species to move across the landscape. Areas with more desirable features are expected to facilitate movement. Areas with few desirable features, and/or areas with barriers, are expected to impede movement. The HPMs developed for OCAMP are not traditional species distribution or habitat suitability models; rather, they illustrate how easy or difficult it will be for a species to move across each part of the landscape. Habitat Permeability Models are built specifically for assessing connectivity and thus evaluate the landscape through the lens of species movement. These models are typically less restrictive than species distribution or habitat suitability models, recognizing that species will often move through less suitable or unsuitable habitat in order to access key resources.

The number and diversity of landscape features relevant to each species varies, but generally included things like:

- Proximity to water
- Landcover types
- Presence of, or proximity to, specific plant species
- Structural components, such as vegetative cover

- Substrate type
- Topography

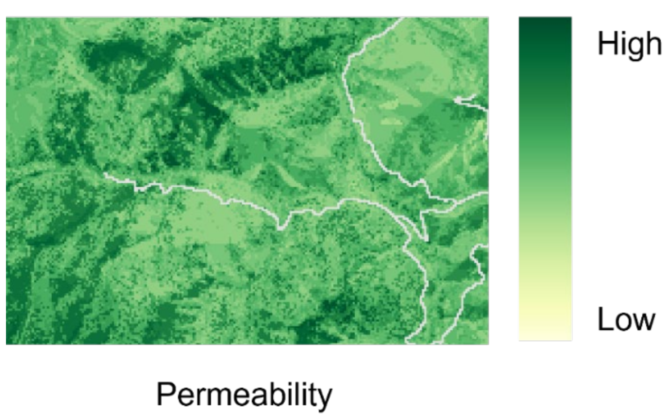
Barriers to movement also vary by species. Common barriers included:

- Linear infrastructure (e.g., roadways, fencing)
- Other human structures (e.g., buildings, houses, renewable energy facilities)
- Agriculture
- Topography

For each important feature identified in the literature review for each species, we used readily available geospatial data to represent that feature in the model, and assigned a permeability score based on whether the feature is expected to facilitate (positive score) or impede (negative score) species movement. For example, beaver are closely associated with water and riparian areas. Parts of the landscape closer to wetlands, rivers, ponds, and lakes would be given a higher permeability score than areas farther away from water sources. Beaver prefer lower elevations, and are typically not found in areas above 4,500 feet. Areas of the landscape greater than 4,500 feet in elevation would be given a negative permeability score, because high elevation areas are expected to impede beaver movement. Certain features on the landscape might be considered absolute barriers that completely block species movement, either through physical impediment (e.g., buildings, solar facilities) or high likelihood of mortality (e.g., interstate highways).

After permeability scores were applied to each individual feature identified by the literature review, we combined all of the relevant geospatial data layers and summed the permeability scores across layers to create the draft HPM.

Example Habitat Permeability Model (HPM)



Areas with many positive permeability scores have a high summed value, indicating highly permeable habitat. Areas with some positive and some negative permeability scores have intermediate summed values, indicating habitat the species might choose to move through if motivated. Areas with primarily negative permeability scores have negative summed values, indicating habitat that is highly unsuitable and expected to severely impede species movement.

Draft HPMs were based on our current understanding of each species' habitat needs, using the best-available research and geospatial data. These models provided important information for assessing species connectivity, but first, they needed to be validated to ensure they accurately represented real-world species habitat use.

Habitat permeability model validation

We used a two-step validation effort for draft HPMs. The first step was a review process, wherein species experts evaluated the models and their individual components and provided their professional opinion on each. We used the feedback provided by reviewers to adjust individual components, as necessary. Following this species expert review, we assessed how well the features and their associated permeability scores aligned with real-world species habitat use by overlapping each individual feature with species occurrence data and applying statistical models to evaluate how well the data aligned.

Species Expert Review

Draft HPMs for each species were reviewed by species experts, including wildlife biologists from ODFW, the Bureau of Land Management, US Geological Survey, US Fish and Wildlife Service, US Forest Service, Oregon Department of Forestry, Universities, Tribes, conservation non-profits, environmental consulting groups, and other non-governmental organizations. Reviewers evaluated the important habitat features identified for the species, the geospatial data used to represent each feature, the permeability scores applied to each feature, and the overall model. Reviewers provided thorough, high-quality comments that aided in improving HPMs prior to statistical validation. Feedback varied by species. The types of information provided included suggestions for:

- Increasing or decreasing the permeability score applied to a feature based on the reviewer's experience with and understanding of the species' habitat needs

- Inclusion of additional features representing habitat requirements
- Inclusion of additional barriers to movement
- Modifications to species range boundaries

Statistical Validation

Following the review process by species experts, we used statistical models to evaluate how well each feature and its associated permeability scores aligned with real-world species habitat use. For each species, we gathered data on species occurrence across its range in Oregon. These data indicate locations the species has been observed, either during formal surveys or incidentally by biologists or community scientists. We then used statistical models to pair the features and permeability scores with the locations the species has been observed to evaluate the extent to which they aligned. Features attributed with higher permeability scores are expected to facilitate species movement, and thus we expect the species to be observed more frequently when that feature is present. Features attributed with lower permeability scores are expected to impede species movement, and thus we expect that the species will be observed infrequently in those locations. Where barriers to movement occur, we expect that it is exceedingly unlikely the species will be observed.

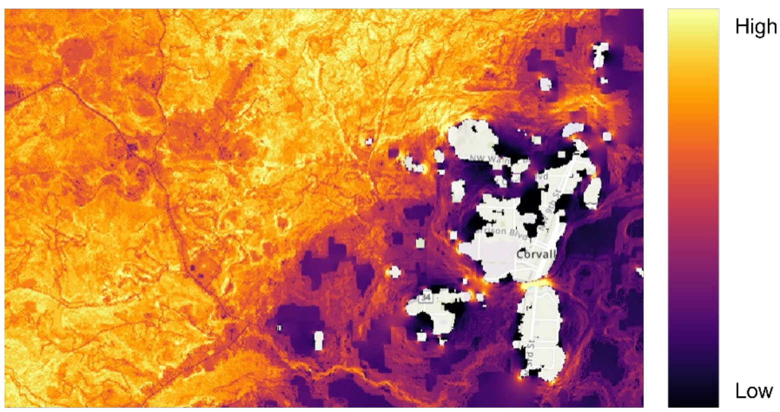
The statistical models highlighted areas where the species occurrence data overlapped more or less than expected based on the permeability scores applied to a given feature. We then could make changes to the permeability scores for that feature to better represent areas of known species occurrence. These adjustments improved the overall fit of the HPMs and ensured that the permeability values accurately characterized areas where the species' movement is more or less likely to be facilitated.

Habitat connectivity modeling

The HPMs are the foundation for the species connectivity models. The HPMs illustrate how each individual part of the landscape is expected to facilitate or impede species movement. The connectivity model then uses that information to assesses the likelihood of movement across the landscape as a whole and predicted connections throughout the species' range.

To develop our connectivity models, we used a connectivity modeling algorithm called Omniscape. Omniscape uses electrical current as a proxy for animal movement. It treats the landscape like a circuit network. Each location on the landscape is assigned a resistance value, just like a circuit network's resistors. In our models, the resistance values are drawn from the HPMs, with more permeable areas having lower resistance. The model then "injects" current into the landscape. The current travels across the landscape based on the underlying resistance values, in the same way individual animals would be expected to travel across the landscape based on the permeability of the habitat. The final output is a map illustrating current flow—patterns of movement among different areas of the landscape.

Example Omniscape connectivity model output



Cumulative Current Flow

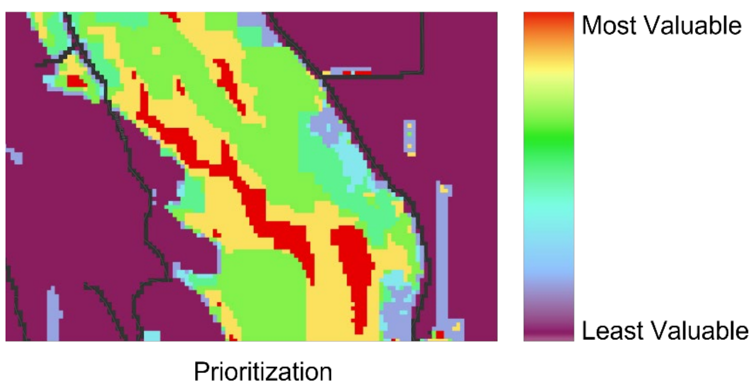
Areas with higher current flow are expected to have more species movement, either due to the presence of high-quality habitat or because of human or natural barriers that cause movement to be constrained or bottlenecked. Areas with low current flow are expected to have little species movement, either due to poor-quality habitat or barriers that would prohibit species use. Areas with intermediate current flow are either representative of marginal habitat, or represent broad areas of quality, intact habitat where animals are able to choose to move freely throughout.

Prioritization

While the connectivity models produced by Omniscape provide information on current flow for each species, the ultimate goal of OCAMP was to identify the parts of the landscape that have the highest overall value for facilitating movement across all project species. To do so, we needed to identify the highest priority connectivity areas from each species' connectivity model. We prioritized each species' connectivity model using Zonation, which is an application of Spatial Conservation Prioritization.

The prioritization process using Zonation starts from the assumption that protecting the whole landscape would be best for conservation of species connectivity. Zonation then removes the areas of the landscape with the lowest connectivity value for each species. In the context of our connectivity models, the lowest value areas are those with little or no current flow, indicating areas that are expected to have little to no species movement. After removing the areas with the lowest value, the entire landscape is reassessed. Zonation then again removes the lowest-value areas of the landscape. This process repeats until the only parts of the landscape remaining are areas that have the highest connectivity value. Zonation retains the order in which different parts of the landscape were removed, which results in a map illustrating a hierarchical ranking of landscape value. From this map, we can identify the highest-value, intermediate-value, and lowest-value areas of the landscape for facilitating movement.

Example Zonation prioritization model output



Compositing species priorities

We prioritized the connectivity model output for all 54 project species. As each project species was selected to represent different habitat associations and structural habitat characteristics, life history strategies, movement capabilities, and response to different types of barriers to movement, combining priorities across all species provided a comprehensive foundation of connectivity need for the state's wildlife. The primary focus of Priority Wildlife Connectivity Areas is to direct conservation action to areas of the state that will have the greatest impact on wildlife connectivity. To this end, we extracted the top 1% of priority areas identified in each species' prioritization model and combined these priority areas across all species.

Combining species priorities resulted in a large number of priority regions statewide, but many of these areas were discontinuous. Although these habitat regions represent the parts of the landscape with the highest overall value for facilitating wildlife movement, without connections between regions any development or land use change occurring around the periphery of a region risks a loss of connectivity if the region becomes isolated from its neighbors. To correct for this and create an interconnected network of priority areas, we built connections between regions using least cost-distance pathways.

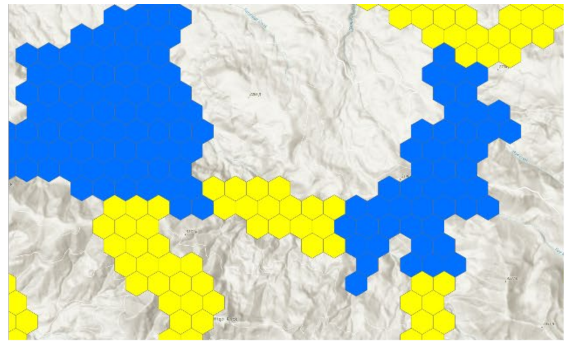
Least cost-distance pathways are identified by: 1) the distance between regions and 2) how easy it is for movement to occur between regions. For example, a longer connection through quality habitat will be selected over a shorter connection through poor habitat. Longer connections might also be required in areas where barriers to movement are present. In some cases, if there are too many barriers to movement, no connection can be made. In determining cost-distance between regions, we factored in additional high priority connectivity areas identified by the prioritization step, as well as climate refugia and riparian climate corridors.

Priority Wildlife Connectivity Areas (PWCAs)

After identifying optimal connections between all regions, we selected our final Priority Wildlife Connectivity Areas (PWCAs) using a grid of 40-acre hexagons. We used hexagons to provide a consistent, minimum patch size and linkage width for PWCAs across the state, and to align with the format of other spatial products developed by ODFW, such as Conservation Opportunity Areas. Additionally, the use of hexagons helps obscure potentially sensitive data encountered at smaller spatial scales. For the final PWCA network, we overlaid a grid of 40-acre hexagons and selected all hexagons that overlapped with the top 1% of species priorities or the optimal connections identified to link those areas. We also added individual or small groups of isolated hexagons in developed areas. Urban areas often do not have enough sufficient habitat to support a fully connected priority area. While these individual or small groups of hexagons are not linked to the network, remnant areas of intact habitat within otherwise developed landscapes still serve to facilitate wildlife movement through cities and are included as "steppingstones" of priority habitat.

Example of delineation of final PWCAs

Priority regions (blue) and optimal connections (red)



Final PWCA Regions (blue) and Connectors (yellow)

To refine our PWCAs we then:

- Filled in gaps of two or fewer hexagons
- Removed any hexagons overlapping developed areas, including cities, airports, rail yards, landfills, feedlots, large industrial complexes, lumber mills, quarries, mines, and solar developments
- Removed hexagons overlapping Designated Wilderness Areas and Crater Lake National Park

Designated Wilderness Areas and Crater Lake National Park are under the highest level of protection possible in Oregon. Given that these areas are under permanent protection, we include only the locations where PWCAs enter or exit these sites.

Interpreting and Using Priority Wildlife Connectivity Areas

Priority Wildlife Connectivity Areas are an informational tool to guide the work of all entities engaged in land, wildlife, and other natural resource conservation and management, including state, federal, county, and local governmental organizations, sportsmen's organizations, conservation groups, NGOs, and private landowners interested in restoring, enhancing, and protecting habitat important for wildlife connectivity. Priority Wildlife Connectivity Areas are not regulatory and do not dictate land use for any public or private entity.

The final PWCA network occupies approximately 25% of the state's area. A total of 53% of PWCAs fall within lands managed by state or federal agencies. The remaining 47% of PWCAs fall within tribal lands, private lands, and industrial lands, as well as lands managed by cities, counties, universities, and other entities. Priority Wildlife Connectivity Areas identified by OCAMP represent the parts of the landscape with the highest overall value for facilitating wildlife movement. Focused investments in habitat within PWCAs can increase the likelihood of long-term maintenance of wildlife connectivity in Oregon, maximize effectiveness over larger landscapes, improve funding efficiency, and promote cooperative efforts across ownership boundaries, resulting in interconnected movement pathways for wildlife in the state.

The network of PWCAs serves as a science-based tool that can be used as a resource, in conjunction with other sources of information, to support habitat enhancement, restoration, and protection, transportation mitigation, and conservation planning efforts, as well as future research and monitoring. Priority Wildlife Connectivity Areas complement other landscape-scale conservation maps, such as Oregon's Conservation Opportunity Areas, indicating areas of the state that are disproportionally important to wildlife connectivity, and can serve as a foundation for future analyses that address specific conservation challenges, such as energy development, human population growth, and climate change.

There are many sectors in which information on PWCAs could help inform both on-the-ground conservation action and planning, including:

- Identification of priorities for land acquisition
- Identification of restoration priorities
- Identification of priorities for transportation mitigation, including siting of new wildlife crossing structures
- Land management plan revisions and decisions for habitat and recreation management for public lands
- Local and county government efforts to protect wildlife connectivity, including incorporation of PWCAs into county planning goals
- Investments through state and federal grant programs for conservation of habitat and working lands
- Informing renewable energy, land use, and waterway planning

Information associated with PWCAs

There are three different types of PWCAs identified in the network: Regions, Connectors, and Steppingstones. Each type was identified for a slightly different purpose and plays a distinctive role in wildlife connectivity.

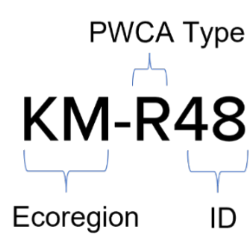
Regions were delineated from the combined top 1% of priorities across all 54 surrogate species. Regions are large, contiguous areas and represent the highest-value habitat for facilitating species movement throughout the state.

Connectors follow the optimal pathways between Regions. Connectors represent the best available habitat for facilitating movement from Region to Region. Connectors may pass through high-quality habitat in intact, relatively undisturbed parts of the landscape, as well as the best remaining marginal habitat in developed or degraded areas.

Steppingstones are individual or small groups of isolated hexagons within urban growth boundaries. Steppingstones represent remnant areas of intact habitat within otherwise developed landscapes that may help facilitate wildlife movement through urban areas.

Each PWCA has a unique name referencing its general location in the state (by ecoregion), the PWCA type, and a numeric identifier. Ecoregions include the Coast Range (CR), Willamette Valley (WV), Klamath Mountains (KM), West Cascades (WC), East Cascades (EC), Columbia Plateau (CP), Blue Mountains (BM), and Northern Basin and Range (NBR). Priority Wildlife Connectivity Areas that straddle or cross two ecoregions are named based on both (e.g., CR/WV). The three types of PWCAs include Regions (R), Connectors (C), and Steppingstones (S).

Each PWCA is named by its location within a given ecoregion, PWCA type, and numeric ID, as diagramed here for Klamath Mountains Region 48



Further, the hexagons within each PWCA contain information. In addition to the PWCA name, each hexagon has a unique name, which includes the PWCA name and is followed by a numeric identifier for that hexagon (e.g., KM-R48-H1 refers to hexagon 1 within Klamath Mountains Region 48). Hexagons also contain information on the general entity (or entities) responsible for managing the land within the hexagon, as well as recommendations for specific types of conservation action. Each 40-acre hexagon in the PWCA network has been attributed with both a Primary and Secondary Recommended Conservation Action. These descriptors are intended to assist the user in determining what actions are needed within a given area to most benefit wildlife movement and conservation of wildlife connectivity in Oregon.

Recommended conservation actions

There are four broad categories of conservation action recommendations: **Protect**, **Restore**, **Transportation Mitigation**, and **Enhance/Maintain**.

Protect: Permanently protecting habitat through acquisition, easement, or long-term management is the principal action needed to secure structural connectivity for wildlife. The single best conservation measure for maintaining wildlife connectivity in the state is to protect remaining undeveloped habitat. All hexagons within the PWCA network would benefit from protection measures, but those hexagons specifically attributed with a Recommended Conservation Action of 'Protect' have been targeted for their value for facilitating wildlife movement. These hexagons represent both the highest-quality habitat available to facilitate movement, as well as bottlenecked areas of movement that risk loss of connectivity if land conversion were to occur. Hexagons attributed as 'Protect' would benefit from targeted measures to protect and preserve habitat, including land acquisition, execution of conservation easements, or specific habitat designation within policy. Some hexagons attributed as 'Protect' fall within public or other lands that are already under some level of protection from development. For these areas, efforts to 'Protect' habitat for wildlife connectivity may benefit from specific management actions, such as road closures, area closures, or other forms of recreation management, removal or modification of grazing leases, avoidance of habitat loss or disturbance from resource extraction activities such as logging or mining, and/or habitat modifications to reduce wildfire risk and remove invasive species.

Restore: In many areas of the state, habitat loss and modification due to development, agriculture, resource extraction, and the spread of invasive species impact functional connectivity for wildlife. While some species may still use these habitats to move, marginal-quality habitats impact the long-term value of the landscape to help facilitate species movement, may hinder the ability of wildlife to adapt to changing conditions, and may be more susceptible to catastrophic events such as wildfire and the spread of disease. As with the category for 'Protect', nearly all of the hexagons within the PWCA network would benefit from some level of habitat restoration or enhancement. Those hexagons attributed with a Recommended Conservation Action of 'Restore', however, are those that have significant overlap with development, agriculture, and/or mapped areas of invasive vegetation. These hexagons in particular would benefit from measures to rehabilitate habitat damaged by human impacts, including actions to remove and prevent reestablishment of invasive species, remove or modify barriers to wildlife movement, and promote native ecological communities.

Transportation Mitigation: Roadways and vehicular traffic are a significant contributor to fragmentation of habitat and impacts to wildlife connectivity. Most species face at least some level of mortality risk associated with roadways, and many species display behavioral avoidance of the activity, noise, lights, vibrations, and smells associated with roads. Any location the PWCA network intersects with a roadway is a potential site for transportation mitigation. However, some roads pose a greater risk to wildlife connectivity than others, based on road width/number of lanes, traffic volumes, traffic speed, driver sightlines, and proximity to higher-quality habitats. Hexagons attributed with a Recommended Conservation Action of 'Transportation Mitigation' are areas of the PWCA network that are particularly susceptible to fragmentation from roadways, as determined both by the value of the surrounding habitat for facilitating movement, as well as known areas of high densities of wildlife-vehicle collisions. Areas designated as being in need of Transportation Mitigation would benefit from installation of wildlife crossing structures or autonomous animal detection systems that would improve wildlife passage across the road.

Enhance/Maintain: Some areas within the PWCA network are at a lower risk of habitat loss due to conversion, represent quality, but not necessarily the highest priority of, habitat available for facilitating wildlife movement, and have limited overlap with development, agriculture, or invasive vegetation. These hexagons have been attributed with a Recommended Conservation Action of 'Enhance/Maintain'. As with the other hexagons in the network, these areas would benefit from protection measures, but specific actions associated with hexagons attributed as 'Enhance/Maintain' could include maintenance of existing conditions that are already favorable to an assemblage of species, avoidance or minimization of adverse impacts that would fragment habitat, removal, modification, or avoidance of the installation of barriers to wildlife movement, and minor habitat enhancements to ensure continued functionality, including prevention of the establishment of invasive species, wildfire risk minimization, and recreation management.

Prioritizing PWCAs

The network of PWCAs within Oregon is extensive, and there may be a desire to further prioritize to identify the parts of the network most in need of conservation action. We anticipate that many entities will incorporate PWCAs into their respective planning and prioritization processes by combining overlap of PWCAs within their area of interest with other sources of information specific to their organizational mission, needs, and goals. In general, however, action within PWCAs may be particularly beneficial when:

- A PWCA supports priority wildlife species, such as Federally- or State-threatened or endangered species, at-risk species, or Conservation Strategy Species/Species of Greatest Conservation Need
- A PWCA is small and/or isolated (such as a steppingstone) or narrow/bottlenecked and may be at risk of loss or disconnection if any land use change occurs
- A PWCA contains unique features, such as rare or uncommon habitats
- A PWCA intersects with other conservation planning tools or habitat priorities (e.g., Conservation Opportunity Areas, aquatic habitat priorities, big game winter range, etc.)
- A PWCA is adjacent to ODFW Wildlife Areas, USFWS National Wildlife Refuges, Designated Wilderness Areas, or Crater Lake National Park
- Land within a PWCA is unprotected