KEY CONSERVATION ISSUES

Oregon’s State Wildlife Action Plan

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KEY CONSERVATION ISSUES

Key Conservation Issues (KCIs) are large-scale conservation issues or threats that affect or potentially affect many species and habitats over large landscapes and seascapes throughout the state. They also affect people by reducing land productivity, reducing opportunities for recreation, altering water supplies, or increasing risk of severe wildfires. As a result, problems impacting large areas must be considered across jurisdictional and ownership boundaries. This section of the State Wildlife Action Plan describes the seven KCIs affecting Oregon, and the recommended conservation goals and actions needed to address them.

The Oregon Department of Fish and Wildlife (ODFW) worked with staff and partners to identify the Key Conservation Issues that pose the greatest potential impact to **Key Habitats** and **Species of Greatest Conservation Need** statewide. They include:

- **Barriers to Animal Movement**
- **Climate Change**
- **Disruption of Disturbance Regimes**
- **Invasive Species**
- **Land Use Changes**
- **Pollution**
- **Water Quality and Quantity**

Each KCI provides an overview of the statewide threat and information on recommended actions. The background text is intended to serve as a starting point for agencies and organizations working on these issues to chart a course to address and adapt to these issues over the coming decade. The background text also serves to inform landowners, natural resource managers, and individuals looking for ideas and rationale for conservation actions.

Many of the KCIs are highly intertwined. For example, changes in fire and flood regimes often happen when land is developed for new communities. Invasive species can be spread as more people move into new areas and can intensify wildfire risk. Climate change acts as a threat multiplier, exacerbating many of the other issues that impact Oregon's landscapes. How these issues play out over the coming decade will be influenced by changes in Oregon's community development patterns, anticipated population increases, policy development, and conservation and restoration activities.

For all recommended actions, implementation will depend on cooperative efforts by a variety of entities and may be contingent on funding, statutory authority, and other factors. Actions need to be compatible with local priorities, local comprehensive plans and land use ordinances, and other local, state, or federal laws. Actions on federal lands must undergo federal planning processes prior to implementation to ensure consistency with existing plans and management objectives for the area. In many cases, these actions are already occurring and should be continued or expanded. In other cases, new actions are identified.

RECOMMENDED ACTIONS FOR ALL KEY CONSERVATION ISSUES

The overall goals for the State Wildlife Action Plan are to promote healthy fish and wildlife populations by maintaining and restoring functioning habitats, preventing declines of at-risk species, and reversing any declines in these resources where possible. Reducing and reversing the impacts of the KCIs can contribute significantly to these goals, while also contributing to healthy human communities. Recommended actions for all KCIs include:

- Working with community leaders in both **urban** and rural areas, and working with agency partners to ensure planned, efficient growth and development, and to preserve fish and wildlife habitats, farms, forest and rangeland, open spaces, and recreation areas.
- Helping landowners and agency partners find reliable and useful information about fish, wildlife, and habitats early in the project planning process.
- Funding, utilizing, and improving financial incentive programs and other **voluntary conservation tools** to support conservation actions taken by landowners and land managers.
- Developing new voluntary conservation tools to fulfill identified needs.
- Promoting collaboration across jurisdictional and landownership boundaries. Integrating information about fish, wildlife, and habitats with collaborative frameworks, such as the Climate Adaptation Framework and the Integrated Water Resources Strategy.
- Helping private landowners, public land managers, and citizens find ways to restore and protect Key Habitats and ecosystem services. Working creatively to find new opportunities and solutions.
- Informing Oregonians of conservation issues and the actions everyone can take that will contribute to Oregon's collective success.

BARRIERS TO ANIMAL MOVEMENT

BACKGROUND

Animal movement is crucial for maintaining healthy populations and ecosystems. **Land use changes** and energy development, including residential and commercial development, conversion of natural habitat for crop and livestock production, resource extraction from activities like logging and mining, transmission lines, power lines and pipelines, water diversions and damming, and transportation infrastructure can all impede fish and wildlife movement. The direct result can be injury or mortality to individuals and biodiversity loss. The indirect result can be fragmentation of fish and wildlife habitat, putting populations at risk and increasing stress on ecosystems and ecosystem services.

Acknowledging the movement needs of species, fish and wildlife managers are working with land managers and the public to provide connectivity for fish and wildlife habitats across the landscape, on public and private lands and even on roadways to allow for safe passage of animals. Providing habitat connectivity is a primary management strategy to maintain species and ecosystem services under a **changing climate**.

AQUATIC PASSAGE

CMP Direct Threats 1, 4.1, 4.3, 7.2

Habitat connectivity is a key component to many facets of terrestrial and aquatic resource management. For Oregon's native migratory fish (NMF), aquatic habitat connectivity is important and contributes to stable and healthy populations. Without habitat access and connectivity, NMF such as salmonids, trout, suckers, mountain whitefish, lampreys, sturgeons, and many others become fragmented across the landscape. This can cause population isolation, increased exposure to disturbance, diminished reproductive potential, and often results in declining population size and reduced recovery capacity. Unimpeded passage provides fish access to critical habitats like spawning, rearing, and foraging habitats which are important for maintaining, recovering, and conserving populations. Obstructions to fish passage can cause migration delays and limit access to habitat, which can result in genetic isolation, thereby making fish more vulnerable to disturbance and mortality. Currently, thousands of miles of historically accessible stream habitat in Oregon are inaccessible to NMF because of manmade, artificial obstructions to fish passage.

Oregon's fish passage laws were in place prior to statehood, but despite these laws, fish passage barriers are prevalent throughout the Oregon landscape. Over time, access to NMF habitats has been blocked or impaired by the construction of impassable culverts, dams, tide gates, dikes, bridges, and other man-made infrastructure. Many of these physical barriers alter natural flow regimes, create drastic changes in water surface elevations, and interrupt the natural transport of sediment and wood, further contributing to habitat degradation or loss. Additionally, water withdrawals and water over-allocation can reduce stream flows to the extent that fish passage is seasonally impaired. Degraded water quality and warm water temperature may also preclude or delay fish passage and act as an environmental barrier to species survival. Improperly sized transportation infrastructure (culverts, bridges and fords) can impair passage of NMF as well as amphibians, reptiles, small and large mammals, and other terrestrial species, forcing wildlife to cross over roads where they are vulnerable to vehicles and predators. Providing passage at artificial obstructions is vital to maintaining, conserving, and recovering Oregon's NMF.

Oregon's fish passage policy (Oregon Revised Statutes 509.580 – 910 and corresponding Oregon Administrative Rules 635-412-0001 – 0065), administered by **ODFW,** requires passage at all artificial obstructions where NMF are or were historically present and prior to when a "trigger" event (e.g., abandonment, major replacement, construction, or fundamental change in permit status) occurs. ODFW works with owners and operators of artificial obstructions in several ways to ensure adequate passage of NMF. Recognizing the unique nature of migratory fish in the Pacific Northwest, many other agencies and groups are also interested in assisting with providing fish passage.

Similar to fish passage, in 1991, the Oregon Legislature established the state's first fish screening statutes (ORS 498.306) and a pilot cost-share program administered by ODFW to assist with construction, installation, and maintenance of fish screening and bypass devices at eligible water diversions. Fish screening and bypass devices can be placed at water diversions (i.e., irrigation systems, hydropower systems) to prevent fish from entering irrigation ditches, diversions, and hydroelectric turbines. **ODFW's Fish Screens Program** is an important part of the **Oregon Plan for Salmon and Watersheds**, a voluntary plan aimed at the protection, restoration, and recovery of NMF, such as salmon and steelhead. Screens and bypass systems that align with current state and federal screening requirements ensure fish stay within natural waterways and are not harmed by diversion structures.

Fish passage and screening restoration are key to helping NMF persist and adapt to changing weather and hydrologic conditions. Addressing fish passage at artificial obstructions and providing fish screening at unscreened water diversion structures is critical to ensure all life stages of NMF and other aquatic and terrestrial species are able to migrate up and downstream and access essential habitat.

AQUATIC PASSAGE: GOALS AND ACTIONS

Goal 1: Provide conditions suitable for natural movement of fish and aquatic animals throughout their native range.

Action 1.1. Continue work with the OWEB, ODOT, ODF, OWRD, USFS, BLM, counties, local municipalities, irrigation districts, tribes, and other partners to inventory, prioritize, and provide fish passage at artificial obstructions, enhancing current work done by the ODFW Fish Passage Task Force to expand implementation of fish passage priorities.

Recently developed methods for prioritization of fish passage that incorporate considerations about transportation infrastructure and climate may help agencies working on these issues in the coming decade. Gathering comprehensive information is an important and ongoing task. Beginning in 2007, the ODFW Natural Resource Information Management Program (NRIMP) began the inventory data management process by creating the **Oregon Fish Passage Barrier Data Standard** (OFPBDS). This standard established the type of information (content), and the format of those data (structure) needed at every artificial obstruction site to accurately inventory and prioritize fish passage obstructions.

After the creation of the OFPBDS, NRIMP began compiling barrier inventory data from multiple sources throughout the state. Data were obtained from local, state, and federal agencies, watershed councils, tribes, counties, and other entities that possessed fish passage barrier data. These data were compiled, standardized to match the requirements of the OFPBDS, and were loaded into a GIS database. **This database** represents the most thorough statewide inventory of artificial obstructions to date and includes information on the number and type of artificial obstructions in the state, as well as the level of fish passage at most barriers, and the physical characteristics of each obstruction. The spatial results of the OFPBDS can be viewed within the ODFW Compass mapping tool.

Ground-truthing is still important to verify the current conditions and severity of individual passage barriers. Artificial obstructions to fish passage are structures, such as culverts, dams, tide gates, and levees, that are placed in fish-bearing streams that preclude or prevent the passage of NMF. In 2015, there were approximately 27,800 documented fish passage artificial obstructions in Oregon. About 17 percent of these barriers were documented as providing adequate fish passage, 21 percent were complete barriers to fish passage (i.e., block all species movement), 19 percent were partial barriers, and 43 percent had a “status unknown passage condition”. Of the 27,800 artificial obstructions, culverts made up the vast majority, with over 23,000 (83 percent) inventoried, while dams are the next most common barrier type with over 2,500 inventoried (9 percent).

ODFW developed, and the Oregon Fish and Wildlife approved, a systematic method to prioritize artificial obstructions based on their value to NMF. **The 2025 Statewide Priority Fish Passage Barrier list** identifies the most critical barriers to fish passage in the state (based on the amount of habitat quality and quantity blocked, current level of passage, number of species in need of passage and other factors) and contains over 600 high priority fish passage barriers. These statewide priority artificial obstructions include dams, culverts, tide gates, fords, bridges, and other artificial obstructions. Dams make up the majority of the “top” priorities. This is due to the fact that dams generally block large segments of habitat on larger river systems. The priority barriers have been organized into groups, with each group representing barriers of similar priority ranking.

All barriers on the Statewide Priority Fish Passage Barrier list are high priorities for ODFW. ODFW will continue to work with local, state, and federal partners to remove or provide fish passage at high priority barriers. Per **state fish passage law**, no new artificial obstructions can be constructed without fish passage, including artificial obstructions used for restoration. ODFW makes recommendations to permitting agencies through conditions on new water right permits, when applicable, to implement Oregon's fish passage law. ODFW's Fish Passage Program will continue to implement fish passage laws when trigger actions (e.g., new construction, major replacement, abandonment, fundamental change in permit status) occur at artificial obstructions, and will continue to encourage other voluntary actions that provide fish passage.

Action 1.2. Maintain and restore habitat to ensure aquatic connectivity in priority areas such as Conservation Opportunity Areas and areas with high road density such as urban centers.

Road-stream crossing structures include culverts and bridges. These structures can impact fish passage and aquatic ecosystems. Many culverts have been placed with the primary goal of moving water past the structure efficiently without consideration of providing fish and wildlife access through the culvert. Minimum streamflow is necessary for fish and other aquatic life to migrate through a waterway. Protecting or restoring the minimum flow necessary for fish passage should be a priority. Poor water quality can also prevent fish from being able to survive in or migrate through an area. Many NMF are sensitive to poor water quality conditions, such as warm instream temperatures, increased fine sediment, low dissolved oxygen levels, or elevated levels of contaminants. Protecting and restoring water quality and healthy riparian corridors should be prioritized.

Road-stream crossing structures, including habitat improvement projects or mitigation, should be designed and built with the goal of maintaining natural flow and hydrological regimes as well as providing a surface or substrate similar to or mimicking natural conditions. This "stream simulation" design goal will ensure the best conditions for passage of both fish and wildlife (including amphibians and aquatic insects). Flow and passage should be maintained through restoration of aquatic habitat connectivity. These efforts should be prioritized based on benefits to aquatic species and location within priority areas, including **Conservation Opportunity Areas** and densely-populated urban centers. Interested parties should also consult ODFW District Fish Biologists and the **aquatic barriers database** to identify high priority habitat for restoration.

In some situations, coordination among responsible parties and interested partners is required to address the effects of obstructions on the hydrological regime. Coordinating with multiple owners across multiple regulatory levels and jurisdictional boundaries can take more time and negotiation to reach an acceptable outcome but is critical to long-term success.

Fish passage structures, such as fishways and culverts, must be carefully designed and constructed to properly function for fish passage. ODFW and the National Marine Fisheries Service have published design criteria for fish passage. ODFW fish passage rules and design criteria can be found **here**. Agency biologists, consultants, owners and operators of artificial obstructions, and other regulatory entities must be aware of and understand the procedures, criteria, and guidelines to ensure that the best possible fish passage solution and stream function are being provided.

Providing fish passage with a fish ladder or properly sized culvert or bridge is an added expense to the owner or operator of an artificial obstruction. However, there are several financial incentive programs that can be of assistance. ODFW has a **cost share grant program** that can help with these costs. There also is a tax credit available for landowners who install qualifying fish screening and fish passage solutions. Other entities, such as the **Oregon Watershed Enhancement Board**, also have funds available for high quality fish passage and habitat restoration projects. Identifying additional funding sources and incentivizing voluntary landowner passage and screening would be greatly beneficial.

Action 1.3. When planning aquatic passage projects, consider the needs of other aquatic species and terrestrial wildlife in addition to fish.

Many efforts to address aquatic passage have emphasized fish, particularly salmonids, but do not necessarily provide adequate passage for all species of fish and wildlife. **Pacific lamprey**, for example, have a distinct set of passage needs that are not often met with common fish passage solutions and facilities. Specialized “lamprey ramps” have been used with success to provide adequate upstream passage for lamprey, and these structures are often needed in addition to salmonid fishways. Similarly, small details within a fishway, such as rounded corners, smooth transitions, and multiple flow paths, can often ensure that fish passage provides benefits to a broad array of NMF species. Although there are currently no requirements to ensure passage for wildlife, ongoing efforts to replace culverts present opportunities for developing, testing, and implementing methods to maximize benefit for a variety of species. Often, minor modifications to fish passage structures, such as dry benches or shoulders, can greatly increase usability for terrestrial wildlife. Aquatic invertebrates would benefit from making culverts as wide as possible to allow lateral movement of the stream. The embedment of culverts with natural streambed materials provides natural stream-like conditions for both aquatic and terrestrial species passage, including amphibians. In addition, maintenance and restoration of **riparian habitat** is important to provide wildlife passage adjacent to in-water habitats.

Action 1.4. Continue to screen unscreened priority water diversions to protect fish, using funds from ODFW's Fish Screening and Passage Cost Sharing Program and working with state and federal funding partners. Implement outreach programs to encourage irrigators to screen intakes, and for construction crews and municipalities to learn best practices for culvert installation.

Irrigation, municipal, industrial, and hydroelectric water diversions frequently cause barriers to movement that can cause fish loss in the millions. Continue to provide **fish screens** at water diversions to keep fish in their natural streams and lakes. Adequately designed screens can keep emigrating salmon and steelhead juveniles, as well as other resident species, from becoming entrained and eventually killed in irrigation diversions or hydroelectric projects. Continued funding, implementation, coordination, and collaboration with multiple stakeholder groups is important for native fish restoration. Provide outreach and technical assistance for irrigators, construction crews, and municipalities.

TERRESTRIAL ANIMAL MOVEMENT

CMP Direct Threats 1, 2, 3, 4, 5.3, 6, 7, 8, 11

All wildlife species need to move, to some extent, to fulfill their needs for survival or complete their life cycles. For some species, this movement may be limited to an area of a few square meters, whereas for others their movements may span multiple continents. Some species move seasonally, following food resources, moving to areas more suitable for raising young, or avoiding harsh winter weather. Young individuals of many species need to disperse into new habitats to establish their own territories. Wildlife may also need to move to escape disturbance, such as wildfires, flooding, and drought. Human-caused changes to the landscape can affect the ability of wildlife to move across terrestrial landscapes by adding obstacles, impacting species behavior, and increasing habitat fragmentation. Habitat fragmentation can have a detrimental impact on many wildlife species, particularly species with small or declining populations.

Buildings, solar energy facilities, roads, fences, power lines, wind turbines, and other structures can serve as obstacles to species movement. Certain types of land use, like crop production and recreation, can also deter or prevent species movement. Movement is a strong urge in wildlife. Some types of movement, like movement along game trails, riparian corridors, or migration routes, are used over decades or centuries by generations of animals. When a new obstacle is developed in the route, like a roadway or a housing development, wildlife may try to find a way through the area, rather than avoid it. This can lead to increased mortality for wildlife and can endanger human safety. In human-dominated areas, wildlife are forced to move through a landscape of buildings, lawns, industrial complexes, and agricultural fields. Some wildlife species are not welcome in developed areas, and human-wildlife conflicts result. Barking dogs and free-roaming cats, lights from houses, security lighting, and streetlights, fencing, vehicle traffic, and other features people take for granted can be frightening or even lethal to wildlife.

Some wildlife undertake long-distance migrations, and need staging or stopover areas to rest and refuel during travel. Habitat conversion or degradation can impact important staging or stopover sites, thus affecting the animals that depend on them. Power lines, tower guy wires, and wind turbine blades introduced into migratory flyways of birds and bats impose aerial barriers to flight.

Connectivity is the degree to which the landscape facilitates wildlife movement, and it is key for wildlife to be able to adapt to changing conditions. Work intended to enhance wildlife connectivity necessitates consideration of a diversity of species, taxa, life history strategies, and responses to different types of stressors that may act as a barrier to movement. How barriers and habitat fragmentation affect wildlife connectivity depends greatly on the species, habitat type, and type of barrier. For example, a two-lane highway may pose a relatively minor barrier to elk but may be impossible for a salamander to cross. A wind energy facility may not impede red fox movement on the ground, but the spinning turbine blades may pose substantial risk to migrating bats.

These issues can be addressed through careful planning and mitigation. Human developments and infrastructure can be designed in ways that avoid crucial movement areas for wildlife. Habitat connectivity can be maintained for wildlife through conservation-based design of interconnected protected areas, maintenance or restoration of habitat corridors within urban areas, development of wildlife crossing structures along roadways, careful siting of renewable energy development and resource extraction efforts, open space conservation, removal of old or unnecessary fencing, and maintenance or restoration of important migratory stopover sites.

TERRESTRIAL ANIMAL MOVEMENT: GOALS AND ACTIONS

Goal 2: Provide connectivity of habitat for the broad array of wildlife species throughout Oregon.

Human-caused changes to the landscape may affect connectivity for individual species in a variety of ways, depending on the species' habitat requirements, mobility, and behavior. Connectivity is species-specific: habitat that facilitates the movement of one species may impede the movement of another, and different species react to barriers to movement in different ways. Maintaining connectivity for wildlife necessitates consideration of a diversity of species and a variety of movement types and must ensure that wildlife can: 1) fulfill their daily, seasonal, and life history needs, including movements between foraging areas, movements to and from sites for breeding and/or rearing young, and migratory movements; 2) disperse into new habitats and territories; 3) maintain genetic interchange between populations; 4) respond to events like wildfires, droughts, and flooding; and 5) adapt to changing climate conditions by moving into new areas to access suitable habitat, sufficient water, and/or tolerable temperatures.

Species with low mobility are at extreme risk of impacts from habitat fragmentation, as they may lack the ability to move away from disturbance. More mobile species may be better able to adapt to habitat fragmentation by dispersing into suitable habitat elsewhere. However, as a result of this greater mobility, these species may also be more likely to come into conflict with humans and human-caused barriers like development and roadways. Accordingly, all of Oregon's wildlife species are susceptible to impacts to connectivity due to landscape change. When evaluating animal movements, consider all types of movement, including terrestrial, in-stream, aerial, underground, seasonal, migratory, dispersal, and nocturnal movement needs.

When new development is proposed, consider its context within the surrounding landscape. Will it obstruct an important movement area for wildlife? How close is it to other developed areas, and what are the cumulative impacts at the landscape scale? Would a higher-density, clustered development leave more open space available for wildlife movement, or would a lower-density development provide greater permeability for wildlife? Leave habitat intact where possible or provide alternative connecting habitat nearby. Work with community leaders, planners, and agency partners to identify and conserve habitat important for movement, like **Priority Wildlife Connectivity Areas**, and to fund and implement site-appropriate mitigation measures.

It is necessary to consider a diversity of habitat types across both urban and rural areas. In developed areas, habitat corridors, such as riparian corridors or urban greenways, may be the only parts of the landscape suitable to facilitate wildlife movement. Outside of developed regions, however, wildlife may move more opportunistically, and larger areas of intact habitat that permit diffuse movement are just as important to maintaining long-term wildlife connectivity.

Action 2.1. Promote conditions suitable for habitat connectivity throughout Oregon.

There is no one-size-fits-all approach for successful wildlife connectivity efforts. The types of actions needed to improve and/or protect connectivity for wildlife will vary based on geography, habitat, species presence, level of disturbance, land ownership, and local, county, state, and federal policies. Permanently protecting habitat through land acquisition, execution of conservation easements, specific designation within policy, or long-term management to promote wildlife use is the principal action needed to secure habitat connectivity for wildlife. The single best conservation measure for maintaining wildlife connectivity in the state would be to protect remaining undeveloped habitat.

In many areas of the state, habitat loss and modification due to development, agriculture, resource extraction, and the spread of invasive species impact connectivity for wildlife. While some species may still use these habitats to move, marginal-quality habitats affect 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. In these areas, habitat connectivity may be restored by working to remove and prevent reestablishment of invasive species, managing landscapes to promote resiliency to wildfire, and promoting native ecological communities.

Wherever possible, remove or modify barriers to enhance connectivity. While habitat use may be species-specific, physical impediments to movement, such as fences, dams, Jersey barriers, and riprap impede connectivity for many species and can carry a risk of injury or mortality for species attempting to cross. Physical barriers can also be created by invasive vegetation. Invasive vegetation may alter habitat conditions needed to facilitate movement of native species, changing habitat structure or out-competing native vegetation used by native species for food or shelter. Invasive wildlife may also impede connectivity of native species, competing with native species for limited resources or preying on native species and/or their eggs or young.

In addition to actions taken to protect, enhance, and restore habitat, wildlife habitat connectivity should be considered in advance of any land use, development, resource extraction, energy, or transportation project or planning process. Incorporate information on wildlife habitat connectivity and key life history needs, consider the diversity of species present that may potentially be affected, and recognize the impacts that any land use change and habitat fragmentation may have on habitat quality and landscape permeability. Avoid habitat development or disturbance within critical movement areas, such as **Priority Wildlife Connectivity Areas**, urban greenways, riparian corridors, and migratory pathways.

Priority Wildlife Connectivity Areas have been identified for Oregon, highlighting the parts of the landscape with the highest overall value for facilitating wildlife movement. Priority Wildlife Connectivity Areas include both areas of good quality habitat within intact, relatively undisturbed parts of the landscape, as well as the best remaining marginal habitat to help wildlife navigate through developed or degraded areas. Each part of the interconnected network of Priority Wildlife Connectivity Areas contains information to assist in determining what types of actions are needed within a given area to most benefit wildlife movement and conservation of wildlife connectivity in Oregon. Guidance is available for the use of Priority Wildlife Connectivity Areas and consideration of wildlife habitat connectivity in the planning and implementation of development, resource extraction, habitat management, and other initiatives that may impact wildlife movement via the **Oregon Wildlife Corridor Action Plan**.

Action 2.2. Enhance wildlife habitat and connectivity with consideration of climate change impacts.

Fluctuations in climate can impact the quality and quantity of wildlife habitat for some species, resulting in potential shifts in species ranges. The range for one species may decline or become fragmented, while expanding for another. Species that can move to more climatically suitable locations will do so by migrating or shifting their ranges as the **climate changes**. Populations that fail to move or adapt risk extirpation or extinction.

Connected landscapes are a critical component of climate resiliency. While habitat loss and fragmentation are the primary drivers of the loss of biodiversity, climate change compounds and intensifies the effects of these issues. Maintaining and restoring landscape connectivity is the most frequently proposed conservation strategy to aid wildlife in adapting to changing climates, enhancing resilience for wildlife populations by enabling them to move with shifting climates and adapt to events like wildfire, flooding, and droughts. Connectivity provides several benefits over alternative adaptation approaches, as it allows wildlife to respond to changes when needed and at their own pace. Additionally, providing connectivity for wildlife helps avoid potential issues with the uncertainties around how different species may respond to different climate stressors, such as changes in temperature, moisture, food availability, and water availability.

The ability of wildlife to shift their ranges, respond to changes in temperature and precipitation, and escape rising waters, severe storms, wildfire, and other climate impacts will be directly affected by the extent to which habitats are connected, as well as the number and location of barriers on the landscape, such as buildings, fences, and roadways. Maintaining or enhancing natural landscapes, providing habitat connectivity, and securing climate refugia are primary management strategies to support species viability in response to a fluctuating climate. Management actions intended to account for climate change will need to be continuously evaluated as new information becomes available to help ensure refugia are developed that support both current and future populations.

Additional actions should focus on reducing the effects of climate-related stressors on wildlife to help support movement and migration. Ensure water sources remain available and accessible to wildlife and consider supplemental provisioning of water in arid or drought-prone areas. Remove or modify barriers to movement wherever possible. Promote activities that promote wildfire resiliency, such as forest restoration and fuels management activities. Provide species with a range of options to adapt to climate change by restoring and expanding areas along a gradient of climates, elevations, and topographic complexities. A landscape-scale network of high quality, interconnected habitats offers an efficient approach to climate adaptation, allowing wildlife to move freely to access resources and tolerable temperatures when needed. A number of maps and tools have been produced to assist with projects and planning efforts to improve climate resiliency in Oregon.

Action 2.3. Work with ODOT, counties, cities, tribes, and other partners to identify and address key areas of wildlife mortality on roadways and consider animal movements when planning for new roads or modifications to existing roads.

Roadways and vehicular traffic are significant contributors 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. Nearly all roads have some potential for transportation mitigation efforts to reduce wildlife injury and mortality. However, some roads pose a greater risk to wildlife connectivity than others, based on factors such as road width, traffic volumes, traffic speed, and proximity of the road to higher-quality habitats.

Wildlife movement should be considered during the planning phase of new roads or projects to modify existing roads. Engage in long-term planning to ensure wildlife passage needs are documented throughout the state, for the full diversity of the state's wildlife species. Avoid high quality wildlife habitat whenever possible and incorporate consideration for wildlife passage in the project design and goals for project outcomes. Incorporate wildlife passage structures and associated directional walls or fencing, with structural elements and features designed to benefit a wide diversity of species. Consider dry land passage for wildlife when removing or replacing culverts under roadways to benefit fish passage—relatively minor modifications to designs for fish passage can greatly improve passage for terrestrial wildlife. Additionally, standalone projects for the construction of wildlife crossing structures should be considered where highways intersect with Priority Wildlife Connectivity Areas. Engage in pre- and post-construction monitoring of wildlife crossing structures to evaluate use and effectiveness over time. Ensure crossing structures and associated features such as fencing are maintained and repaired as necessary.

Continue to collect data to better identify high-priority sites for mitigation. **Priority Wildlife Connectivity Areas**, telemetry data from wildlife movement studies, carcass data collected by road maintenance crews and public salvage, Traditional Ecological Knowledge (TEK), and community science data, such as observations recorded through the **Roadkills of Oregon** project on iNaturalist, can help identify areas where vehicle-related mortalities for wildlife are of high concern. Transportation mitigation may still be beneficial in the absence of any documented roadkill if the traffic volumes, speeds, and/or road width have made the road a complete barrier to species movement. Additional research may be needed to advance understanding of wildlife-transportation corridor conflicts, as well as design approaches, so that preventative, cost-effective solutions can be incorporated into project designs.

Action 2.4. Consider animal movement when planning new energy development and resource extraction activities.

Energy production and resource extraction activities such as logging and mining often have significant impacts on wildlife and wildlife habitat. For example, federal requirements for solar facilities mandate perimeter fencing at a minimum height of six feet, completely blocking movement and habitat access for all but the smallest terrestrial species. Identify optimal locations for siting of new projects or facilities, avoiding **Priority Wildlife Connectivity Areas** and other areas important for wildlife movement and migration. Consider potential impacts to both local species and to long-distance migratory species. Integrate information on wildlife connectivity into environmental review and permitting processes. Research and monitor the impacts of energy development and resource extraction on species movement.

Action 2.5. Promote strategies to improve permeability of agricultural areas for wildlife.

Agricultural landscape use, including crop production and livestock grazing, can have varying effects on wildlife movement. Some types of agriculture can provide co-benefits for wildlife, whereas others create risks for human-wildlife conflict. Consider wildlife movement and migration when planning for agricultural production. Mitigation techniques, such as the use of **prairie strips** between row crops, may help lessen the impacts of crop production on wildlife. Low-intensity and diversified production permit greater movement of wildlife. **Wildlife-friendly fencing** allows for livestock containment while lessening the risk of injury or mortality to wildlife from fence entanglement, making fenced areas more permeable to wildlife movement. Provide financial incentives for agricultural management activities that benefit species movement, such as the **Wildlife Habitat Conservation and Management Program**, **Riparian Lands Tax Incentive Program**, or **Oregon Farm Bill Programs**.

Action 2.6. Promote strategies to increase permeability of urban landscapes for wildlife.

While urban landscapes are often highly modified, some wildlife species have adapted to use these spaces, and many species will take advantage of remnant natural habitats in areas like riparian corridors, parks, open spaces, greenways, and preserves. Many of these high value steppingstones across urban areas have been identified within **Priority Wildlife Connectivity Areas**. A multitude of actions can be taken to benefit wildlife movement within developed areas. Examples include connecting urban natural areas and riparian corridors, supporting and promoting the use of green infrastructure in urban planning, reducing noise and light pollution, and reducing direct hazards to wildlife, such as minimizing avian collisions with windows. For more information, see the section on **Conservation in Urban Areas**.

Action 2.7. Promote strategies to reduce the impacts of outdoor recreation on wildlife movement and habitat permeability.

Human recreation in natural environments can affect the willingness of wildlife to use habitat, even in high-quality habitat areas. Activities like hiking, biking, foraging, hunting, fishing, camping, skiing, and off-road vehicle use can create sensory stressors for wildlife, with sound, light, and unusual smells that may deter species from moving through certain areas. Human recreation may contribute to destruction of sensitive vegetation, harassment of wildlife from off-leash pets, spread of invasive species, and contamination of areas with refuse. Many species will avoid areas near trails, campgrounds, and access roads when humans are present. Recreation management can help mitigate these impacts, balancing the need for human access to natural spaces with wildlife habitat needs. Institute road and/or area closures to protect species during sensitive times of year and decommission roads when possible. In high-use regions, establish permitted entry systems to decrease recreational pressure. Restrict off-road vehicle use, including motorized vehicles, snowmobiles, electric vehicles, and bicycles in priority areas. Limit recreation activities near wildlife crossing structures. Explore additional legal and funding avenues to increase law enforcement of travel management plans and motorized vehicle restrictions. Consider **Priority Wildlife Connectivity Areas** in the development of long-term management plans for public lands. Continue to research the impacts of outdoor recreation on wildlife behavior, movement, and fitness.

Action 2.8. Identify, maintain, and restore important stopover sites for migratory wildlife.

Not all species that rely on habitat within Oregon are year-round residents; many reside outside the state and visit Oregon while traveling elsewhere to breed or overwinter. Species on long-distance migrations may use habitats within Oregon infrequently, only relying on stopover sites to rest and refuel, but these areas are as essential to wildlife survival as the territories they occupy for longer periods. To fully address wildlife connectivity, connectivity planning efforts within the state must consider the habitat needs of these long-distance migratory species, such as birds, monarch butterflies, and bats. Impacts to habitat used as migratory stopovers can contribute to population declines of species that spend most of the year beyond Oregon's borders.

Use existing information on the location and value of known stopover sites when planning for new development. Many sites, such as wetlands and mudflats, are in lowland areas which are often targeted for development. Some areas, such as agricultural fields, can be important for migrating birds, especially shorebirds. Work with partners to maintain and restore priority sites, such as **The National Audubon Society's Important Bird Areas** or **important shorebird areas**. In particular, look for ways to avoid or minimize impacts on important sites. If impacts are unavoidable, mitigate impacts by providing alternative sites nearby and minimize disturbance during critical migration periods, such as the spring and fall. Seek opportunities to work with landowners to provide and enhance habitat for migrating wildlife. Engage in cross-boundary partnerships to help promote conservation of wildlife habitat both within and outside of Oregon to benefit migratory species.

Action 2.9. Continue to collect terrestrial wildlife movement data and refine maps and models to better understand wildlife habitat permeability and connectivity.

Two types of information are crucial to understanding wildlife movement and habitat connectivity: (1) documented wildlife occurrence, including wildlife observation data as well as fine-scale data tracking movement pathways of individual animals, and (2) geospatial maps and models for vegetation, topography, habitat structural characteristics, barriers, and other aspects of the landscape that might influence species movement and habitat use. Both empirical observations and modeled data are useful in mapping landscape permeability and connectivity for wildlife. Information should be made available to planning organizations and the public to facilitate conservation of habitat.

Geospatial data required to accurately depict habitat quality for wildlife are often inadequate or nonexistent, and many of Oregon's wildlife species have significant data gaps, both in occurrence data identifying species presence on the landscape and in basic understanding of species' life history processes, such as habitat requirements and drivers of movement, that allow for effective modeling and mapping of species connectivity. Some features on the landscape that might influence movement have not been mapped (e.g., noise attenuation, light pollution), have been incompletely mapped (e.g., fences, solar facility footprints, logging access roads, fire severity, diversion channels, trails, soil types), or have not been mapped at a fine enough resolution (e.g., talus, colluvium, grassland cover/types, forb cover, stream morphology/flow/depth/substrate) to adequately inform understanding of wildlife movement and habitat connectivity. Additionally, the scale of many existing geospatial data layers does not capture all relevant landscape features that might influence wildlife movement, particularly for smaller-bodied and/or less-mobile species.

Engage in research to verify species habitat use and requirements, including identification of any significant impediments to movement. Prioritize research on under-studied species, particularly Species of Greatest Information Need and Species of Greatest Conservation Need. Collect additional wildlife occurrence data, including Traditional Ecological Knowledge, placing emphasis on acquiring observation and movement data to help statistically validate connectivity model output. Many species lack sufficient occurrence data for evaluation of habitat connectivity, particularly small mammals, reptiles, and invertebrates. Prioritize development of fine-scale, statewide geospatial habitat maps and models for features important to wildlife connectivity, including vegetation classes, shrub cover, and other structural habitat features. Identify and map locations of potential barriers to movement statewide, including fencing, roadways, solar facilities, diversion channels, and trails.

ADDITIONAL RESOURCES

Fencing with Wildlife in Mind

Wildlife Crossing Structure Handbook Design and Evaluation in North America

Roadkills of Oregon

Facilitating Wildlife Passage through Fish Culverts

USFS Wildlife Crossings Toolkit

Freshwater Connectivity Toolkit

ODFW Fish Passage Requirements

Land Trusts and Wildlife Crossing Structures

Connectivity and Climate Change Toolkit

ODFW Solar Siting Guidance

Making Renewable Energy Wildlife Friendly

Metro Habitat Connectivity Toolkit

IUCN Guidelines for Conserving Connectivity through Ecological Networks and Corridors

Oregon Wildlife Foundation Trail Planner’s Guidebook

Prairie Strips to Enhance Wildlife Movement through Agricultural Areas

Marine Connectivity Conservation ‘Rules of Thumb’

CLIMATE CHANGE

BACKGROUND

CMP Direct Threats 11.1, 11.2, 11.3, 11.4, 11.5

The Earth’s climate has changed throughout history due to a variety of factors, with corresponding changes to natural systems. However, in recent centuries, humans have significantly altered the composition of the atmosphere by burning fossil fuels for energy and clearing forests and other natural habitats, contributing to accelerated changes in climate conditions.

There is clear and growing evidence that our continued use of fossil fuels and conversion of natural lands for other uses is increasing the concentration of carbon dioxide and other greenhouse gases in the atmosphere and is a primary contributor to the significant rise in global temperatures that has been observed since about 1950. This increase in greenhouse gases in the atmosphere is primarily because humans have burned and continue to burn fossil fuels for transportation and energy generation. Industrial processes, deforestation, and agricultural practices also increase greenhouse gases in the atmosphere. According to the Intergovernmental Panel on Climate Change (IPCC), the United Nations body for assessing the science related to climate change, the evidence is unequivocal that the earth is warming at an accelerated rate due primarily to human activities, and that there have been and will be significant changes to the global climate this century.

Rising temperatures and other direct and indirect climate effects of increased greenhouse gases make up the body of interrelated trends referred to as climate change or global warming. These substantial shifts in global climate variables are observable in today’s climate, and they are expected to increase and accelerate through at least the next century or until well after human-caused emissions of greenhouse gases are returned to much lower levels. As a result, climate change will cause irreversible alterations to both human communities and ecological systems globally.

Several broad-scale changes have already been observed, including:

- Loss of glaciers, ice sheet mass, and sea ice
- Increases in ocean heat content and marine heatwaves
- Ocean acidification and deoxygenation
- Sea level rise and coastal erosion
- Shifting rainfall patterns and more frequent heavy precipitation
- Shorter winter seasons and earlier spring and summer seasons
- Warmer nighttime temperatures and an increasing number of hot summer nights
- Increasing inland water temperatures

- More frequent and severe wildfires, heat waves, flood-producing storms, and regional droughts
- Changes in species distribution (such as land and ocean species shifting poleward)

Climate change will bring significant impacts not only to fish, wildlife, and their habitats, but also to working landscapes and rural, urban, and tribal communities. These impacts include threats to water resources, rangeland degradation due to invasive species and increased drought, increases in wildfire, pest outbreaks in forests, alteration of oceanographic regimes, and changes to aquatic, terrestrial, and marine communities. Many of the available approaches to helping fish and wildlife adapt to climate change can also help human communities cope with these changes.

CHANGES TO THE GLOBAL CLIMATE SYSTEM

Atmospheric concentrations of planet-warming gases are increasing, including the three main greenhouse gases produced by human activities: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Since 1850, carbon dioxide concentrations have increased by more than 47%, nitrous oxide by 23%, and methane by more than 156%. The concentration of CO_2 in the atmosphere as of 2024 (about 425.5 parts per million) is the highest known level in at least the past 2 million years, and probably much longer, and it continues to rise rapidly. In the absence of strong mitigation measures, 21st century emissions are projected to approximately double the current atmospheric concentrations of CO_2 by 2100. Substantial efforts to reduce or stabilize emissions could help limit the concentration to 600 ppm CO_2 or less.

The most direct effect of the rise in carbon dioxide and other greenhouse gas concentrations is a warming of the air and water. Global average temperatures over the past decade were about 2°F warmer than the pre-industrial period. Each of the years from 2014-2022 was ranked globally as one of the nine warmest on record.

In addition to warming temperatures, major impacts from increases in greenhouse gases include ocean acidification and sea level rise. The ocean is a natural carbon sink and has absorbed 20-30 percent of atmospheric CO_2 increases. Dissolved CO_2 then forms carbonic acid and subsequently dissociates into bicarbonate and hydrogen ions, which increase sea water acidity. The surface of the open ocean is the most acidic since at least 26,000 years ago, and current rates of change in acidity are unprecedented since at least that time. Additionally, global average sea levels over the past decade were higher than in the preindustrial period by between 7 and 9.5 inches, with more than half of this rise occurring since 1980. Relative to 2020, an additional 11 inches of sea level rise is expected along the U.S. coastline by 2050, with a likely range of 9–13 inches. Sea level rise will vary across U.S. coasts, with greater impacts expected to the East and Gulf Coasts than the West Coast.

CLIMATE CHANGE IN THE PACIFIC NORTHWEST

The Pacific Northwest, including Oregon, contains diverse ecosystems and landscapes encompassing nearshore kelp forests, estuaries, rocky shorelines, wet temperate forests, snow-packed volcanic mountains, dry coniferous forests, and large expanses of dry sagebrush steppe. In addition to supporting thousands of native species, these ecosystems also provide food, housing, recreation, and income that support the health and well-being of almost 14 million residents. Communities in the region have been employing various climate adaptation strategies, but additional efforts to mitigate climate change will be essential for the long-term effectiveness of adaptation actions. Climate change has already impacted ecosystems across the Pacific Northwest and these effects will continue to cause transformational change across the region.

Increases in air and water temperatures

As of 2025, average annual air temperatures in Oregon have warmed by 2.5^{0}F since 1900. Over the 21st century, annual average temperatures are projected to increase by an average of 4.7°F under a low-emissions scenario (SSP1-2.6) and by an average of 10.0°F under a very high emissions scenario (SSP5-8.5).

Seasonal coastal upwelling causes nearshore sea surface temperatures off the Oregon and Washington coasts to be cooler than offshore surface temperatures. Nonetheless, annual average coastal sea surface temperatures in the Northwest have warmed approximately 1.2°F since 1900, and the northern California Current, which extends northward from northern California to the northern tip of Vancouver Island in Canada, is projected to warm by an additional 4.6°–7.3°F by the end of the century under a very high emissions scenario (RCP 8.5).

Warming has also been observed in freshwater ecosystems, with warming trends in stream temperatures throughout the Pacific Northwest, including Oregon. Average annual water temperatures in lakes and streams are projected to continue to rise. Increases in stream temperatures are more pronounced during summer and early fall months when stream flows are lowest.

Changes in water and snow availability, streamflow, and drought

As air temperature increases, the capacity of the atmosphere to hold water vapor increases and the rate of evaporation increases. These changes impact the timing, form, and quantity of precipitation, which alters hydrology in lakes, rivers, streams, aquifers, wetlands, and upland systems. In general, a greater share of precipitation falls in fewer events, which simultaneously increases the frequency and severity of both floods and droughts.

Between 1915 and 2024, average snowpack declined by 21% in the western U.S., representing a loss of water storage capacity that is twice as large as that of Crater Lake. Mountain snowpack has been declining as winter temperatures increase, particularly in areas with warm maritime climates, and a greater proportion of winter precipitation is falling as rain rather than snow. Snow-line elevation is also increasing as snow-dominated watersheds transition to mixed rain-and-snow watersheds and mixed rain-and-snow watersheds transition to rain-dominated watersheds. More frequent, longer, and more severe regional drought conditions will increase as summer precipitation continues to decrease, exacerbating wildfire risk and reducing water availability.

Interannual variability in precipitation is projected to persist, and summer streamflow is expected to decrease further from reduced snow storage, increased evapotranspiration, and longer lags between summer rain events. It is projected that some permanent streams will transition to ephemeral streams, affecting aquatic species and ecosystems as well as regional water supplies.

Changes in wildfire frequency and intensity

In the Pacific Northwest, wildfires are increasing in size, frequency, and intensity. Area burned has increased steadily and dramatically across the western U.S. since the 1980s. Warming temperatures lead to an increase in evaporative demand. When evaporative demand is high, the land loses more water to the atmosphere through evaporation and transpiration, leading to drier vegetation, exacerbating the risk of burning. Concurrent heat and drought have become more common, resulting in increased fuel loads as amounts of stressed or dead vegetation in many landscapes continue to increase. Additionally, many previously burned forests are reburning. Reburns can produce abrupt shifts in forest structure and composition, including transition to non-forest vegetation, when they occur over shortened intervals. Indeed, in low-elevation and drier areas, some forests are converting to shrubland after wildfires, and these ecosystem transitions are becoming more common across the Northwest.

The average annual area burned in Oregon’s forests is expected to increase by at least 50%, and fire seasons are expected to become more extreme than any in recorded history. From 1979 through 2019, the duration of the fire weather season in forests of Washington, Oregon, Idaho, and California increased by 43%, and the annual number of days when fire danger was extreme increased by 166%. In fire-prone areas of the western United States, including the mountains of Oregon, the annual number of extreme, single-day wildfire expansions is projected to increase by 100% if annual average temperatures increase by 3.6˚F above the 2002–2020 average. The number of wildfires in national forests in the Pacific Northwest is projected to increase by 20–140% by 2070–2099 under very high emissions scenario RCP 8.5, varying based on forest characteristics and regional weather patterns. Furthermore, the total area at risk of high fire danger in summer in the northwest is projected to increase by 345% under RCP 8.5.

Non-native annual grasses, including highly flammable cheatgrass, ventenata, and medusahead have rapidly expanded in perennial grass systems, arid woodlands, and sagebrush ecosystems. The establishment of these invasive species is associated with relatively high precipitation during autumn and spring and with ground disturbance from wildfire, livestock grazing, recreation, and other types of land use. These species grow in spaces between sagebrush or other shrubs and perennial grasses that were historically bare of vegetation, which significantly increases fuel loads, the ability of fire to spread, and fire intensity.

Additional stressors to habitat, including recreation, development, transportation, and energy transmission, will also continue to affect wildfire frequency in both shrubland and forested systems. The length of the wildfire season and the potential for human-caused ignitions in all Pacific Northwest ecosystems are expected to increase as drought frequency, duration, and intensity increase.

Wildfire smoke also poses a major threat to human and wildlife health. Due to increasing wildfire activity in late summer and autumn in the Pacific Northwest, air pollution from wildfire smoke is projected to double under a moderate emissions scenario (SSP2-4.5) or triple under a high emissions scenario (SSP5-8.5) by end-of-century.

Extreme events

In addition to changes in long-term averages in temperature and precipitation, climate change is increasing the frequency and severity of extreme weather events, including heatwaves, drought, and severe storms. Along with the increased water-holding capacity of warmer air, higher air temperatures indicate an increase in the average energy of air molecules; this energy can manifest as movement, resulting in higher wind speeds and more powerful weather.

The frequency and intensity of extreme precipitation events are projected to increase across the region, particularly because of an expected rise in the number of strong atmospheric river events, producing significant amounts of rain or snow for longer durations. An atmospheric river is a flowing column of condensed water vapor in the atmosphere responsible for generating substantial quantities of rain and snow, especially in the Western United States, which can lead to flooding, landslides, and other damage. Impacts of atmospheric rivers are also projected to reach farther inland and last longer in the future. Understanding how climate change alters the frequency, intensity, duration, and reach of atmospheric river events will be critical for estimating how the region's water supply will change.

The frequency and intensity of heatwaves are also expected to increase in both terrestrial and marine systems and will have broad-ranging impacts. Terrestrial heatwaves refer to a period of abnormally hot weather lasting two or more days. In terrestrial systems in the Pacific Northwest, an "extremely warm day" is a day on which the maximum temperature is 90°F (32°C) or above. The number of "extremely warm days" has increased significantly across Oregon since 1951, and the magnitude and duration of heatwaves are expected to continue to increase. Marine heatwaves refer to a period during which water temperature is abnormally warm for the time of the year relative to historical temperatures, with that extreme warmth persisting for days to months. The phenomenon can manifest in any place in the ocean and at scales of up to thousands of square kilometers. Widespread and persistent high sea surface temperatures have been shown to temporarily increase onshore temperatures by up to 11°F above regional averages, resulting in short-term shifts in species distributions and mortality of many seabirds and marine mammals. These heatwaves also increase the toxicity of harmful algal blooms, posing significant risks to fish and wildlife, as well as people who consume crabs and other shellfish.

Sea-level rise

Under all future climate scenarios, sea level is projected to increase across the Pacific Northwest, although net sea level changes will vary by location. Long-term climate cycles, such as El Niño, also influence sea level and can raise sea levels up to an additional 7.9 inches for periods of several months. Wave height and tidal surge are also projected to increase. Relative to the 1991–2009 average, sea levels in the Pacific Northwest are projected to rise 0.6 to 1.0 feet by 2050 for the intermediate- and high- emissions scenarios, respectively, placing physical structures and communities at risk. This expected rise will cause total water levels to increase and change coastal flood regimes, with major and moderate high-tide flood events occurring as frequently as moderate and minor high-tide flood events occur today.

Higher sea levels also contribute to erosion and tidal flooding, increase the likelihood of damaging storm surges during storm events, and increase the salinity of surface water and groundwater systems. Furthermore, mechanisms to protect infrastructure from rising seas, like shoreline armoring, can have additional negative effects on coastal and marine ecosystems. As sea levels rise, coastal species and habitats will need to migrate inland, which may not be possible for species in locations adjacent to developed communities or transportation infrastructure.

Ocean acidification

Ocean acidification is the process by which the pH measurement of ocean water becomes more acidic due to the absorption of carbon dioxide. Human-caused carbon emissions have already influenced ocean acidification of waters off the coast of Oregon. Since the beginning of the Industrial Revolution, roughly one-third to one-half of the CO_2 released into Earth's atmosphere by human activities has been absorbed by the oceans. During that time, scientists have estimated that the average pH of seawater declined from 8.19 to 8.05, which corresponds to a 30% increase in acidity. Concentrations of atmospheric CO_2 are expected to continue to rise, leading to more CO_2 absorbed by the oceans and further increases in ocean acidity.

Ocean acidification has significant negative effects on marine organisms. As ocean acidity increases, it becomes more difficult for species such as oysters, clams, mussels, crabs, sea urchins, corals, and certain types of plankton to build and maintain shells. Larger animals, such as squid and fishes, may experience negative impacts from increasing acidity as acid concentrations rise in their body fluids. This condition, called acidosis, may cause problems with respiration as well as with growth and reproduction. Further, some algal species benefit from more acidic conditions, with increased growth and toxin production as ocean acidification increases, contributing to more frequent and severe harmful algal blooms. Increases in ocean acidity commonly co-occur with other stressors like warmer temperatures or reduced oxygen, leading to cascading effects on food webs and human communities.

Ocean hypoxia

Hypoxia, or the condition of low levels of dissolved oxygen within the water column, is a naturally occurring phenomenon that has increased in frequency over the last century. Hypoxia can be caused by a variety of factors but changing climate conditions have increased the frequency of occurrence of hypoxic conditions in the ocean. Anoxic events (zero oxygen) have also started to occur. Hypoxic conditions are harmful to marine life, as low oxygen levels directly affect the fish and invertebrates that live in these areas, which require dissolved oxygen in the water to breathe. The effects of ocean hypoxia on fish and shellfish are varied and differ by species. As dissolved oxygen content decreases, mobile organisms will avoid or move out of the area, shifting species distributions. Species that cannot move to more oxygenated waters may die during hypoxic events.

Warming sea surface temperatures also increase stratification of the water column, which affects oxygen availability. Stratification is a condition in which surface and subsurface waters are separated by differences in temperature or salinity. This layering prevents oxygen-rich surface waters from replenishing the oxygen in the bottom waters, increasing hypoxic conditions in subsurface waters. Warming sea surface temperatures also reduce oxygen saturation in the water column and increase species' metabolic rates, which can further diminish oxygen availability. Climate-induced changes in wind patterns and intensity affect coastal currents, altering patterns of upwelling which can bring deoxygenated water to the sea surface. Shifts in upwelling patterns may also cause mismatches in the timing of important life cycle events for marine species. Increased precipitation contributes to more water, sediment, and nutrient runoff into coastal zones, where they are likely to increase eutrophication, leading to further stratification and increases in hypoxia.

Compounding stressors

Climate change interacts with other stressors, often amplifying effects and complicating management responses. Species, habitats, and ecosystem processes are threatened by multiple longstanding and ongoing stressors, including habitat loss, fragmentation, degradation, overharvest and destructive harvest, pollution, invasive species, and disease agents. Alone or in combination, these compounding stressors can reduce a species' potential to adapt to changing conditions, making it more difficult for species to persist. Climate change acts as a "threat multiplier" by magnifying the effects of existing stressors on species and ecosystems. The severity of these compounding stressors and their interactions with climate change will drive the overall vulnerability of most ecosystems. Resource managers must therefore confront climate impacts in the context of the other natural and human-induced changes that are already significantly affecting species, habitats, and ecosystems. Successful species and habitat conservation will require an increased understanding of these complex interactions of climate change and compounding stressors.

Examples of compounding stressors that may be exacerbated by climate change include:

- Increased spread and damage from invasive species, native pests, and pathogens
- Increased availability, transport, uptake, and toxicity of environmental pollutants
- Intensification of harmful algal blooms (HABs) in freshwater, marine, and estuarine systems and subsequent hypoxia (low or depleted oxygen in the water), associated with the overgrowth of certain algal species
- Increased conflict between people and fish and wildlife as distribution of species and timing of life cycle events change

As climate change intensifies existing threats to species and ecosystems, resource managers must confront many uncertainties. No single strategy will ensure that ecological communities can adapt and survive. However, reducing the impact of compounding stressors is often one of the most effective strategies to increase the resilience of species and ecosystems. For example, reducing habitat fragmentation and increasing connectivity of intact habitats makes it easier for wildlife to move and track shifting resources as climate conditions change.

IMPACTS OF CLIMATE CHANGE ON FISH AND WILDLIFE

Climate change is causing innumerable direct and indirect impacts on species and their habitats. Consequently, species must respond by either shifting in space (seeking more suitable conditions elsewhere) or persisting in place (adapting to tolerate changing conditions). Populations that fail to move or adapt risk extirpation or extinction. A steadily growing body of scientific literature has documented responses to climate change including altered abundances, distributions, health, morphology and growth, timing of life cycle processes, and behavior. These species-level changes are having cascading impacts on the overall structure and function of ecosystems.

Changes in air, water, and sea-surface temperatures, altered patterns of precipitation, and other climate change stressors can have a variety of impacts on fish and wildlife, including:

- Earlier arrival of spring-like conditions and changes in the timing of biological events, such as migration, reproduction, and flowering, potentially leading to mismatches in the life cycles of interdependent species
- Arrival of exotic pests and pathogens, and increased insect damage from existing pests in some forest ecosystems
- Prolonged periods of low flow and high temperatures in streams, resulting in warming of freshwaters beyond thermal tolerances of some aquatic species
- Increased introduction, spread, and dominance of invasive plant and animal species
- Drying of some freshwater wetlands and headwater streams
- Shifting hydrology, resulting in changes to the distribution of aquatic and marine species

Each of these impacts has the potential to significantly alter fish and wildlife populations and their habitats. Some climate stressors will directly jeopardize the success of species that are dependent on specific habitat components, while other impacts may be indirect. For example, ocean acidification may lead to direct loss of organisms that build shells or other calcified structures, such as oysters, clams, sea urchins, and corals. Loss of these species may then destabilize food webs, as well as economies that depend on marine harvests.

Although some species and ecosystems are undoubtedly being harmed by climate change, others may prove surprisingly durable. Species that can move to more climatically suitable locations will do so by migrating or shifting their ranges. Range shifts have already been noted for many species, including poleward and elevational movements of many insects, birds, fish, and vegetation communities. However, the rapid rate of change and the fragmentation of habitat will make it more difficult for many species to move. Additionally, some species may not be able to shift because they have limited mobility, movement is blocked by geographic or anthropogenic barriers, or because suitable habitat is not available elsewhere. These species may need to alter their behavior or the timing of life cycle processes, like reproduction, to respond to changes in habitat conditions such as food availability, habitat loss, and novel species interactions.

While some generalist species may continue to thrive in a changing climate, the rapid rate of climate change, compared to past shifts in climate, means that species adaptation may have to occur very quickly for species to be successful. Evidence indicates that most species will not have the capacity to keep pace with the rate and magnitude of climate change through evolutionary adaptation alone, particularly since adaptive capacity is often constrained by factors such as barriers to movement, disease, or invasive competitors. Species that are negatively affected by climate change will likely include species with limited movement and dispersal and those with very specific habitat and/or diet requirements, including species that depend on high elevation, cold water, or wetland habitats. Low reproductive rates, long generation times, low genetic diversity, and complex life histories are additional traits that tend to increase vulnerability and have already led to threatened or endangered status for some species. Migratory species are also likely to be strongly affected by climate change, as these animals require multiple habitats along movement pathways (increasing the chances of reliance on an impacted resource) and often rely on environmental cues to trigger migration.

Maintaining and recovering species that are already imperiled is expected to become increasingly difficult. If species are unable to adapt to the rapidly changing environment caused by climate change, they could become locally extirpated. Native species that are adapted and restricted to certain conditions may face extinction. For example, the ranges of small mammals in mountaintop habitats are contracting along with the snow caps, and some of the state’s native frog populations are declining due to the seasonal increases in temperature and associated drying of wetlands.

RESPONDING TO CLIMATE CHANGE IN OREGON

Adaptation to climate change is occurring across multiple sectors, including natural resource management, but at a pace and scale that is insufficient in relation to the pace and scale of climate change. While thoughtful planning is essential, the accelerating speed of climate change means that resource managers and decision-makers cannot wait for the perfect plan to guide decisions; rather, they must move forward now with existing tools and information. For example, in 2020, ODFW adopted a Climate and Ocean Change Policy that provides high-level direction to ODFW on responding to a changing climate and ocean conditions through science and proactive leadership. The Climate and Ocean Change Policy includes the following key goals, to be implemented through key principles identified in the Policy:

1. Ensuring ODFW understands the risks and opportunities associated with climate and ocean change, and incorporating into ODFW's actions to maximize the conservation, use and enjoyment of fish, wildlife and their habitats for present and future generations.
2. Providing leadership towards a coordinated statewide and regional response to minimize impacts to natural resources and the communities, culture and economies reliant on them.
3. Increasing public awareness regarding the current and future impacts of climate and ocean change on fish, wildlife and their habitats, and the value of resilient habitats.
4. Providing leadership towards achieving the reductions in global greenhouse gases emissions through reducing ODFW's carbon footprint.

Climate change is forcing natural resource managers to think more creatively and—in many cases—embrace new and different approaches to address the unprecedented challenge and magnitude of climate change impacts. Cultivating an experimental mindset to test new and innovative ideas will be essential to meet the challenges imposed by climate change.

The Oregon Ocean Acidification and Hypoxia (OAH) Council was formed in 2017 to address issues related to ocean acidification and hypoxia. The OAH Council created both a Communication Plan and an Action Plan to help inspire and guide people to act to help reduce the effects of ocean and climate change at multiple levels in our society. The Oregon OAH Action Plan identifies ways that governments and individual Oregonians can make a difference to slow these impacts and adapt to the changes that are already happening. The Action Plan is scheduled to be revised every six years.

In 2022, the Association of Fish & Wildlife Agencies (AFWA) provided general recommendations for resource managers when incorporating climate adaptation into management plans. These included:

1. Adopt forward-looking goals
2. Explicitly link actions to climate vulnerabilities
3. Manage for change, not just persistence
4. Consider broader landscapes/seascapes and longer timeframes
5. Address uncertainty by considering future scenarios and use of adaptive management
6. Engage diverse partners with climate experience and expertise

[Spotlight] The Crystal Springs Creek Restoration Project

The Crystal Springs Creek Restoration Project in Portland is a model of urban ecological restoration that directly supports climate adaptation for fish and wildlife. Crystal Springs Creek is a 2.7-mile tributary of Johnson Creek, located in southeast Portland. Crystal Springs Creek is spring fed, which keeps water temperatures cool and stream flow uniform throughout the year. This adds cool water to Johnson Creek in the summer when stream flow can be low and warm. In 2006, the Oregon Department of Environmental Quality listed Crystal Springs Creek as an impaired waterbody due to elevated summer temperatures. Warm water in Crystal Springs Lake flowing into the creek, undersized culverts, and concrete banks were identified as key problems for fish and wildlife.

Recognizing the creek's potential as a thermal refuge for threatened species such as coho and Chinook salmon and steelhead trout, the City of Portland and its partners, including Reed College, Metro, and the Johnson Creek Watershed Council, have worked for over a decade to restore Crystal Springs Creek. The restoration effort has included the replacement of fish-blocking culverts to improve connectivity, the addition of large logs, root wads, and boulders to slow water and create pools for fish, the removal of invasive vegetation, and the addition of thousands of native plants to improve bank stability, reduce pollution, and provide shade.

The Crystal Springs Creek restoration effort has not only enhanced fish passage and spawning habitat, but has also improved climate resilience, helping to buffer the creek from climate-driven impacts like drought, extreme heat, and flooding. A restoration plan for Crystal Springs Lake would further improve conditions for fish and wildlife in Crystal Springs and Johnson Creeks by reducing heat loading from the lake.

Crystal Springs Creek now serves as a living demonstration of how urban waterway restoration can serve dual purposes: recovering endangered species and building long-term ecological resilience. By reconnecting fragmented habitats, restoring native vegetation, and reducing vulnerability to climate extremes, the project offers a blueprint for cities across the country aiming to integrate nature-based solutions into climate adaptation strategies.

Resources for supporting climate adaptation:

- The Climate Toolbox
- USDA Climate Hub Adaptation Menus

Voluntary Guidance for States to Incorporate Climate Adaptation in State Wildlife Action Plans and Other Management Plans. Association of Fish and Wildlife Agencies, 2022.

Principles and Key Elements of Managing Natural Resources in the Face of Climate Change

ODFW Climate and Ocean Change Policy

Advancing the National Fish, Wildlife, and Plants Climate Adaptation Strategy into a New Decade. National Fish, Wildlife, and Plants Climate Adaptation Network (NFWPCAN), 2021.

Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment. National Wildlife Federation, 2011.

Climate Change Vulnerability Index

Oregon Climate Action Commission

Oregon Climate Action Commission Natural & Working Lands Fund Annual Report

NOAA Sea Level Rise Viewer

Climate Adaptation Knowledge Exchange (CAKE)

Pacific Coast Collaborative

International Alliance to Combat Ocean Acidification

Many federal and university partners in the region have expertise in delivering science products to support resource managers in taking action on climate adaptation:

- Oregon Climate Change Research Institute
- USGS Northwest Climate Adaptation Science Center
- University of Washington Climate Impacts Group
- USDA Northwest Climate Hub
- Northwest Climate Resilience Collaborative

GOALS AND ACTIONS

Goal 1. Use the best available science, technology, and management tools to determine the vulnerability of species and habitats to climate change at a landscape scale.

Climate change is a global issue, and the responses of fish, wildlife, and habitats to changing climate conditions will play out across political boundaries and will require a new, more integrated approach to management. As a result, evaluation and planning needs to be done at a landscape scale that can be applied to range-wide conservation planning for fish, wildlife, and their habitats. Landscape-scale conservation recognizes the importance of large, interconnected land- and seascapes to maintaining biodiversity, and considers the needs of wildlife, ecological processes, and human communities holistically to achieve conservation goals. Many species may shift ranges so that they are no longer found within the borders of a particular state or protected area. Therefore, efforts to evaluate and mitigate vulnerability should focus on how a species or their habitat will respond across its range, accounting for the full array of life cycle functions.

Action 1.1. Work with partners to increase information on climate change vulnerability of habitats and species.

Building a body of information on climate change impacts and the vulnerability of Species of Greatest Conservation Need and Key Habitats is an important first step to guiding management and policy decisions on climate change. Management priorities should drive the scientific information that is gathered to inform decisions. Collaboration with research institutions, such as the **Oregon Climate Change Research Institute**, **Northwest Climate Adaptation Science Center**, **NOAA Northwest Fisheries Science Center**, and **University of Washington's Climate Impacts Group**, nonprofits, tribes, and government agencies can help increase understanding of climate change vulnerability without overtaxing limited budgets. Many of these institutions are leading ongoing efforts to identify the most vulnerable species and habitats and develop assessment models for these species. Meaningful, multi-sector stakeholder engagement will be essential to advance our understanding of these complex issues.

Action 1.2. Support long-term research on climate trends and ecosystem responses.

To provide the necessary information on climate impacts on species and habitats, research and monitoring efforts will need to be conducted over longer periods of time. Funding and institutional support will be needed to encourage long-term research. Existing long-term ecological research programs, such as **Oregon State University's (OSU) H.J. Andrews Experimental Forest**, the U.S. Forest Service's (USFS) experimental forests, **the Northwest Fisheries Science Center's long-term ocean environment monitoring**, and the **ODFW's Lifecycle Monitoring Sites** can be a cornerstone of such efforts. The results from these research efforts should be used to inform and adapt management strategies, monitoring protocols, and objectives for Species of Greatest Conservation Need and Key Habitats.

Action 1.3. Develop and implement monitoring and evaluation techniques for vulnerable Species of Greatest Conservation Need and Key Habitats.

Because of the changes expected under future climates, new decision tools will be needed to help determine appropriate management actions. There is a need to develop monitoring protocols that can quickly detect climate-related shifts in populations and habitats, help tie existing and proposed management with on-the-ground results, and inform and refine vulnerability assessments. Evaluating actions will be critical to coping with future climate uncertainties. To make the most efficient use of available funding, monitoring should be coordinated and shared among relevant agencies and organizations. Monitoring across boundaries and jurisdictions will form the basis for decision-making in a variable and rapidly changing environment and allow habitat protection and restoration efforts to focus on vulnerable, high priority areas.

Goal 2: Identify, prioritize, and implement conservation strategies to mitigate the negative impacts of climate change on fish, wildlife, and habitats.

Action 2.1. Incorporate currently available climate change information into management plans for species and habitats. Focus on strategies that are robust to a range of potential future climates and that maintain or restore key ecosystem functions and processes.

Future climate conditions will vary in unpredictable ways; however, waiting for more details is not the best approach. Instead, it is important to make use of the best available information to immediately identify and implement adaptation strategies for Oregon's species and habitats. Examples of some of these strategies may include:

- Improving the connectivity of natural landscapes to better link fish and wildlife populations, allow animals to access habitats that meet their specific needs, and allow for range shifts
- Identifying and designating climate refugia where species and ecosystems are most likely to persist, even under high impact scenarios
- Limiting or mitigating new water uses where water quality and/or quantity is already degraded
- Identifying and protecting cold water rearing and refugia habitat for aquatic species, (e.g., Cold Water Habitat designations by Oregon Department of Environmental Quality)
- Setting population targets and management goals with future climate conditions in mind
- Looking for opportunities to protect species and habitats in their likely future locations

One way of coping with uncertainties about future climates and the responses of species and habitats is to focus on identifying and implementing management approaches that are likely to be successful under a range of climate scenarios. For example, scientists have a very high level of confidence that temperatures in the Pacific Northwest will continue to rise over the next several decades, on the order of 1-5°C by mid-century. However, it is less clear how precipitation patterns are likely to change. Efforts to identify robust adaptation strategies for a particular species or habitat might involve considering two or more climate scenarios with different degrees of warming and precipitation conditions. Management actions that are likely to be successful under multiple scenarios are preferable to those that only make sense under a narrow range of future conditions.

Because future climate conditions may not support the same fish, wildlife, and plant species found in Oregon today, another promising approach is to focus on restoring abiotic conditions in ecosystems. These might include actions that:

- Improve water quality and quantity
- Increase natural water storage on the landscape
- Maintain nutrient cycling processes
- Promote an ecologically appropriate disturbance regime
- Protect soil health

Some researchers have even suggested that conservation planning should be based on geophysical classes rather than biological communities.

Action 2.2. Minimize other threats.

Many of the best available climate change adaptation strategies involve managing other threats to species and habitats. Because rapidly changing climate conditions will interact with, and may exacerbate, the other Key Conservation Issues (KCIs) described in Oregon's SWAP, working to reduce these other threats is a good way of moderating the effects of climate change on fish, wildlife, and habitats. Reducing non-climate threats also tends to be a low-risk approach with a relatively high likelihood of success, because many non-climate threats are better understood, managers have more experience in applying action plans, and the actions taken are not as dependent on the accuracy of future climate predictions. For example, protecting an interconnected, representative network of natural and semi-natural lands for long-term conservation management is one of the most effective tools for coping with both climate change and other conservation threats, because relatively intact ecosystems are more likely to be more resilient to climate change, will better sustain fish and wildlife populations facing climate threats, allow wildlife to move to adapt to changes at their own pace, and may even transition more smoothly to future climate conditions.

Action 2.3. Develop regional and local partnerships to coordinate responses to climate change across political, cultural, and jurisdictional boundaries.

Climate change is a global phenomenon, and it greatly increases the importance of working across traditional boundaries to more effectively manage fish, wildlife, and natural systems. Coping with the challenges of a rapidly changing and less predictable climate will require stronger working relationships with both traditional and new partners at various scales. Some opportunities include:

- Using the work of regional and national efforts, such as the **Association of Fish and Wildlife Agencies' Climate Adaptation Committee**, to identify policy options and goals for multiple agencies and organizations to address common concerns related to local, regional, and national impacts of climate change.
- Working with agencies, tribes, and stakeholders from different sectors to develop consensus-based regional policies that inform and direct local decisions on climate change. Both the causes and effects of climate change are closely linked to human communities, and the impacts of climate change on natural communities cannot be successfully managed in isolation from human systems.
- Developing comprehensive education and outreach tools for the public on the impacts of climate change on fish, wildlife, and their habitats.
- Providing information on climate change and its impact on both human and natural communities will help generate public support for adaptation efforts. Local and regional governments and citizen-based nonprofits and organizations (e.g., Soil and Water Conservation Districts, watershed councils) can help develop and deliver these educational materials to their constituents.
- Strengthening current partnerships and collaborations, and developing new ones, to pool funding and resources, improve data and information sharing, and encourage cost-effective strategies for addressing climate change impacts and adaptation.
- Incentivizing conservation on private lands using financial and tax incentives, grant programs, and conservation agreements.
- Collaborative planning with climate vulnerable communities to identify shared values and opportunities to sustain fish and wildlife populations and improve habitat that also help protect human communities from climate change impacts.
- Establishing mutual goals for managing species and habitats in response to climate change. Potential partners include: the **U.S. Geological Survey (USGS) Forest and Rangeland Ecosystem Science Center**, the Department of the Interior regional **Climate Adaptation Science Centers**, U.S. Fish and Wildlife Service (USFWS), Bureau of Land Management (BLM), National Marine Fisheries Service, and other state and federal agencies, academic institutions, non-governmental organizations, and tribes.

- Developing interagency and intra-agency strategies to identify research needs and share data can help reduce costs and avoid duplicative efforts.

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DISRUPTION OF DISTURBANCE REGIMES

CMP Direct Threats 7, 8.1, 8.2, 10, 11

BACKGROUND

Many habitats are naturally maintained by disturbance. Disturbance in terrestrial, freshwater, and marine environments, including fire, floods, wind, storms, volcanic eruptions, earthquakes, landslides, and coastal upwelling has historically played a key role in shaping many of Oregon's native habitats. Natural disturbances shape Oregon's landscapes by resetting plant succession, releasing nutrients, moving materials, creating new habitats, and maintaining native habitats, such as grasslands, savannas, and rocky intertidal zones. Many of these disturbance regimes, however, have been altered by human activities, with impacts to fish, wildlife, and their habitats. Development and habitat fragmentation, industrial logging, agriculture, energy development, and changing climate conditions have impacted disturbance regimes in both aquatic and terrestrial ecosystems.

Altered fire regimes have changed vegetation patterns, which affect wildlife species that rely on fire-adapted landscapes. Fires have become statewide issues as Oregon's population has grown, placing homes and communities closer to where these disturbances occur. Fire suppression techniques were adopted to protect valuable timber as well as human life and property. The unintended consequences of fire suppression have included altered plant species composition, distribution, and density and increased fuel loads. By removing less extreme wildfires, suppression can lead to a greater likelihood of more intense, high-severity fires in the future.

Dams were constructed to control water for various purposes such as protecting towns from flooding, producing electricity, storing water, and providing water for irrigation. Some unintended consequences of dam construction include impeded or blocked aquatic passage, as well as changes in hydrologic regimes that resulted in loss of floodplain function, loss of fish spawning and rearing areas, degraded riparian habitats, and alteration of nutrients and sediment introduced to marine environments. These disruptions to natural hydrologic regimes have all affected Oregon's fish and wildlife populations.

Climate change has also impacted ecosystems across the Pacific Northwest. Climate change is leading to shifts in the frequency, intensity, and duration of natural disturbances like fires, floods, and insect outbreaks. Climate change interacts with other stressors, such as habitat loss and degradation, often amplifying effects and complicating management responses. Understanding these interactions is crucial for effective conservation and management strategies.

Many species have evolved in response to natural disturbance regimes, so mimicking these regimes can help maintain or restore their populations. By simulating natural disturbances, managers can ensure that the ecosystems continue to function to support a variety of species and ecological processes, as well reduce risks to people.

ALTERATION OF OCEANOGRAPHIC REGIMES

Nearshore ecosystems depend on dynamic oceanographic processes such as coastal upwelling, sediment transport, and freshwater inputs. Alteration of oceanographic regimes can stem from both anthropogenic stressors (e.g., climate change or altered flow regimes from dams), or from natural factors (e.g., El Niño and the Pacific Decadal Oscillation). In recent years, marine heatwaves have become a common disturbance in the Pacific Ocean that has impacted Oregon's nearshore environment and its species.

Coastal upwelling, driven by spring and summer northerly winds, provides cold, nutrient-rich waters to replace warmer surface waters. The surge of nutrient from upwelling has a profound effect on ocean productivity, with associated ecological and socioeconomic implications. The particular pattern of upwelling that starts in early spring and then occurs intermittently through the spring and summer is part of the reason Oregon's nearshore ecosystem is so productive. There is growing evidence that, over time, upwelling will vary in intensity, be less intermittent, and start later in the year, primarily due to changes in wind patterns resulting from global climate change. As the climate warms, ocean mixing due to wind patterns will be less effective at bringing nutrients to the surface, thereby reducing primary productivity and disrupting food webs. These shifts in patterns of upwelling are expected to change nearshore ecosystems, but the exact nature and severity of changes is unknown. Water temperature is also a key factor in determining the strength of upwelling in the nearshore, with higher temperatures inhibiting mixing because layers of warm surface waters mix less easily with colder, deeper water.

Sediment transport is also important to maintaining nearshore habitats. The Oregon coast has a naturally complex shoreline consisting of beaches, estuaries, and rocky shores. Jetties, breakwaters, and other man-made structures built out into the water can alter the depth and shape of nearby sand bottoms and can alter localized oceanographic characteristics such as patterns of currents and sediment transport. Shoreline stabilization structures, such as riprap and seawalls, have been constructed in many developed areas along the Oregon coast to protect coastal property from erosion due to wave action. These structures can block or alter the natural littoral drift of sand along the coast and can deprive some beaches of sand, while increasing the deposition of sand in other areas.

Changes to freshwater inputs, due to alteration of the hydrologic regimes in upper freshwater systems, can also impact estuarine and nearshore environments. Dams can change the amount and timing of freshwater influx into estuaries and the nearshore ocean. This may result in an alteration of river plume fronts within the marine environment, including changes in the direction of flow of the river plume, availability of nutrients and sediment being brought into the marine system, and changes in water chemistry composition from suppressed mixing of fresh and saltwater. These alterations can in turn affect the species that are dependent on river plume microhabitats and alter species composition within the area.

ALTERED FIRE REGIMES

Changes in Wildfire Frequency and Intensity

Since the early 2000s, Oregon has experienced a rapid escalation in the number of catastrophic wildfires and associated home and property losses, suppression costs, and worsening ecological conditions on the land. The total area of land burned by wildfire each year has also increased in Oregon since 1980s, and wildfires have grown larger and have spread into higher elevations during this period. Warming temperatures lead to an increase in evaporative demand. When evaporative demand is high, the land loses more water to the atmosphere through evaporation and transpiration, leading to drier vegetation, exacerbating the risk of burning. Concurrent heat and drought have become more common, resulting in increased fuel loads as amounts of stressed or dead vegetation in many landscapes continue to increase. Climate change driven drought, increased aridity, and reductions in relative humidity contribute to increased fire risk in Oregon. In the Pacific Northwest, the number of days with extreme wildfire danger have more than doubled since 1979. The length of the wildfire season and the potential for human-caused ignitions in all Pacific Northwest ecosystems are expected to increase as drought frequency, duration, and intensity increase.

Fire Suppression and Uncharacteristically Severe Wildfire

Oregon's landscape is made up of multiple natural fire regimes. The term 'fire regime' refers to the typical frequency, intensity, duration, aerial extent, and seasonality of wildfire disturbance in a particular ecosystem, with reference to the historic range of variability for these disturbance patterns. Fire regimes are influenced by factors such as forest type, climate, and ignition source. Differences in fire regimes have had a significant impact on the biodiversity, structure, and function of ecosystems. Understanding fire regimes is crucial for managing wildland fire, restoring ecosystems, and mitigating the impacts of climate change.

For thousands of years, fire has been one of the most important forces shaping Oregon's landscapes, both forested and unforested. Before colonization, Indigenous tribes across

Oregon managed their lands with fire. With frequent low intensity burns, the land was stewarded to improve hunting and gathering of traditional foods and medicinal plants. With the arrival of Euro-American settlers, these fires were prohibited, and wildfires were aggressively extinguished. This loss of regular low intensity fires has had profound effects across the landscape.

Human intervention to prevent and extinguish wildfires over the last hundred years has altered the historical fire regimes in many of Oregon's landscapes. This has resulted in a cascade of unintended consequences for ecological health, wildlife populations, and people. Past forest practices and fire suppression have resulted in young, dense stands where open, park-like assemblages of mature trees once dominated. These denser forests are at an increased risk of forest-destroying crown fires, disease, and damage by insects.

Shading from encroaching trees and fire suppression has also reduced the vigor of shrubs and other understory vegetation, altering understory habitats and forage availability for many species. Coupled with warmer drier conditions caused by climate change, the consequences of fire suppression are expected to lead to more landscape-scale, higher-severity fires in Oregon. Active forest management (e.g., prescribed burns, fuels reduction, thinning) can help lower wildfire risk, improve forest health, and protect timber assets.

Forested Landscapes

In forested areas, vegetation changes following fire suppression have increased the likelihood of wildfires that are uncharacteristically large, severe, or both. The extent of change in natural fire regimes varies considerably among forest types. For the purpose of discussing fire, forests typically are grouped into three broad categories:

1. Drier forests that are or were dominated by species like ponderosa pine, Douglas-fir, and larch historically tended to experience frequent fires (average intervals between fires of less than 25 years) that burned small trees and shrubs, but had limited effects on overstory trees with thick, fire-resistant bark. This pattern of frequent, low-severity fires is often referred to as an understory fire regime.
2. Intermediate environments, such as mid-elevation areas supporting forests comprised of a variety of conifer species, had average fire return intervals ranging from around 25 to 100 years. The impact of fire on overstory trees could vary from minimal to severe (depending largely on weather and topography). This associated fire regime is often referred to as a mixed fire regime.
3. Forests in moist, cold areas (or at least with cool summers, as in the Coast Range or high elevation mountains) tended to experience infrequent fires (average intervals of more than 100 years) that killed most or all the dominant trees, leading to a stand-replacement fire regime.

The greatest extent of alteration to natural fire regimes has occurred in forests that historically had an understory fire regime. These forests are **ponderosa pine** and some mixed conifer forest types in the **East Cascades**, **Blue Mountains**, and eastern (interior) portion of the **Klamath Mountains** ecoregions. Human intervention, particularly fire suppression, past selective logging of large overstory trees, and high reforestation stocking standards associated with modern silvicultural practices have shifted the historical fire regime from an understory fire regime with frequent, low-intensity fires to a stand-replacing fire regime with less frequent, high intensity fires. Additionally, extreme fire weather is driving more large fires and burning all forest types at high severity, even those may have experienced low intensity burns under less severe circumstances.

The elimination of frequent, low-intensity fires resulted in increased fuel loads in the form of surface fuels, smaller trees, and increased stand densities. Increased stand densities favor understory trees like Douglas-fir and grand fir. Dense understory trees serve as “ladder fuels” that link surface fuels and overstory fuels. Selective logging removes the larger, more fire-tolerant trees and opens the canopy, allowing smaller, fire-sensitive trees to grow in the understory. The increase in fuel loads and stand densities makes it more likely that when fire does occur, it will reach the forest canopy and spread as a crown fire. As a result of increased stand densities, larger trees become stressed due to competition with other vegetation for water and becoming more vulnerable to crown fires and more prone to insect infestation and disease.

Because of their large size and intensity, severe fires are more likely to cause adverse economic and environmental impacts. Fire has a negative economic impact on rural communities in Oregon whose economy and culture are based on timber products manufacturing and distribution. Fire-fighting activities are a major expense for the state. The cost of fighting fires has increased dramatically with fire suppression costs exceeding $120 million in 2020 and 2021 and in 2024, fire suppression costs were over $250 million.

Uncharacteristically severe wildfires also pose higher risks to species and habitats because such fires can involve large areas and often result in complete mortality of overstory and understory vegetation (i.e., stand-replacing events). In September 2020, wildfires burned almost as much forest west of the Cascade Mountain crest in 2 weeks as in the previous five decades. These stand-replacing fires can impact habitats, soils, and watersheds beyond their adaptive limits. Uncharacteristically severe wildfires impact aquatic habitats by removing riparian vegetation, which results in higher stream temperatures, decreased bank stability, and increased sedimentation in stream channels.

Many Oregon forests at a higher risk contain **Key Habitats** or other important habitats for **Species of Greatest Conservation Need** . Many of the Late Successional Reserves (LSRs) designated under the **Northwest Forest Plan** for management to preserve and produce late-successional forests are located in high risk areas. These LSRs address the habitat needs of late-successional and old-growth forest-related species, such as the **Northern Spotted Owl** or **Marbled Murrelet**. Many riparian areas that provide habitat for fish species listed under the Endangered Species Act (ESA), including **Chinook salmon**, **coho salmon**, **steelhead**, and **bull trout**, are also potentially at risk.

Sagebrush, Grassland, Oak, and Aspen Habitats

Fire historically maintained many sagebrush, grasslands, oak savannas, oak woodlands, and aspen woodlands by removing competing vegetation and stimulating regeneration of native fire-associated plants. Fire suppression has allowed shrubs and conifers to encroach into **grasslands**, **oak woodlands**, and oak savannas. Similarly, it has allowed western juniper to encroach into **aspen woodlands**, some **riparian areas**, and mountain big sagebrush habitats. Maintenance of these habitats over time will require the careful reintroduction of natural fire regimes using site-appropriate prescriptions, accounting for the area size and vegetation characteristics that affect resiliency and resistance to disturbance. In some areas, other techniques, such as mowing or controlled grazing, can be used to mimic the effects of fire.

Vegetation in sagebrush steppe ecosystems is adapted to arid conditions and strongly influenced by fire and by drought. Drought, defined as two growing seasons with below average precipitation, has a pronounced impact on shrubs, grasses, and forbs. Drought can reduce sagebrush growth and impact grasses and insect populations, which can in turn result in less food for **Greater Sage-Grouse** and lower chick survival.

The issues of altered fire regimes and **invasive species** interact to create unnatural fire cycles in eastern Oregon, particularly in the **Northern Basin and Range** ecoregion. The introduction of invasive annuals, particularly cheatgrass and medusahead, can increase the frequency, intensity, and spread of fires. Breaking this cycle will require proactive management to prevent the introduction of annual invasive species, minimizing the spread of cheatgrass, controlling wildfires in invasive-dominated areas, avoiding prescribed fire in cheatgrass-dominated areas, and conducting research on how to better restore areas dominated by invasive species. Habitats formerly dominated by sagebrush and native grasses that are now dominated by invasive annuals do not always meet the habitat needs of native wildlife, such as the Greater Sage-Grouse.

ALTERED FIRE REGIMES: GOALS AND ACTIONS

Goal 1. Reduce uncharacteristically severe wildfire and restore fire or ecologically equivalent action in fire-dependent ecosystems to reestablish vegetative structure and species composition representative of a typical disturbance regime for forested and other systems.

Action 1.1. Use wildfire mapping tools to identify local zones with greatest risk of uncharacteristically severe wildfire and prioritize further action. Refer to restoration needs assessments to prioritize local zones for restoration action.

Mapping tools such as the US Forest Services **Wildfire Crisis Strategy Landscapes** can be used to identify some of the areas at highest risk of catastrophic wildfire and prioritize local sites for management actions to reduce risks. Setting priorities is essential, due to the magnitude of the areas requiring restoration and the limited resources allocated to their treatment. The risk of losing key ecosystem components is a factor that should be considered, with priority given to areas that currently at a moderate or high risk of losing key ecosystem components.

In identifying priorities for fuel reduction techniques, consider both local site-specific conditions and the broader landscape context. Site-specific considerations should include identification of particular values at risk of loss from uncharacteristically severe wildfire, such as remnant large-diameter ponderosa pine, oak, madrone, and other dead snags. Larger-scale considerations should include factors such as the extent to which an area's landscape context makes it highly valuable to wildlife (e.g., travel corridors, breeding locations) or more likely to be vulnerable to fire or contribute to fire spread. Similarly, proximity to human residences or high-value watersheds needs to be considered.

Action 1.2. Work with landowners, managers, and other partners in these zones to lower risk of wildfires while maintaining wildlife habitat values, and to choose the sites and landscapes for fuel reduction and forest restoration.

Community-based forest health collaboratives are well-established and widespread across Oregon. These collaborative partnerships have provided review and recommendations for federal forest management activities occurring near their communities. These groups identify local forest health priorities through a community-based process, develop landscape-scale forest restoration plans, and develop agreement on active management and restoration approaches. Collaboratives bring together representatives from federal, state, and local governments, conservationists, timber interests, tribes, and other local groups to develop a clearly defined vision and strategic goals for cooperative restoration. The work of local forest collaborative partnerships has been shown to be an important means for establishing local support and agreement for forest restoration treatments, thereby increasing the potential for an acceleration in the pace and scale of forest restoration. For example, the **Rogue Forest Partners** have implemented cohesive restoration in the dry Southwest zone.

To provide guidance on how to address the threat of wildland fires to communities and natural resources, the US Forest Service has developed the **US Forest Service's Wildfire Crisis Strategy (Strategy)**. The Strategy is intended to increase the scale and pace of forest health treatments on federal, state, tribal, and private lands by prioritizing sites and landscapes for treatment. In 2024, the **Collaborative Wildfire Risk Reduction Program** was announced as part of a larger initiative to expand the Strategy and to provide funding to enable wildfire risk reduction efforts. The Oregon Department of Forestry (ODF) is also leading development of **Oregon's 20-year Landscape Resiliency Strategy** with private, local, tribal, state, and federal partners to improve forests and rangelands to reduce wildfire risk. Partners can use the priorities outlined in the ODF's Resiliency Strategy to align priority actions and investments to the places of greatest need.

OSU's **Oregon Forest Management Planning** site provides guidance and resources to woodland owners and forestry professionals who are writing forest management plans.

For many thousands of years, native peoples and tribes used fire to manage landscapes. A challenge for land managers today is to incorporate the Traditional Ecological Knowledge of indigenous peoples and tribes into standard fire management plans to reduce fire risk without harm to culturally significant resources. Partnerships among tribal leaders, agency and tribal land managers, and other interested parties will help to move some landscapes closer to a resilient condition. Co-development of management plans will ensure that all priorities are included and addressed.

There are a variety of management practices, tools, and regulatory mechanisms that private landowners can employ to reduce the probability and/or effects of large fires. Active forest management (e.g., thinning, prescribed burns) can be used on private lands to reduce fire risk. Additionally, private land managers can help mitigate the negative effects of drought and improve overall forest stand health by planting more fire tolerant native conifer species, maintaining required tree spacing densities, and managing for pest/disease outbreaks.

Action 1.3. Seek and support cost-effective methods for reducing fuels, especially innovative approaches that increase the pace and scale of forest restoration and contribute to local economies.

Social acceptance for fuel management and other wildfire reduction efforts is likely to be greatest where various interests and values converge (for instance, in an accessible area of dry forest types where restoration would protect residences, restore or conserve habitats of concern, and provide a commercially valuable timber by-product that could be processed in a local mill). Given the great disparity between the extent of areas needing treatment and the limited resources to accomplish the necessary treatments, careful consideration of factors related to social acceptance, as well as fire risk and other ecological elements, should help identify areas where projects can both provide substantial benefits and have a high likelihood of being successfully implemented.

In some areas, carefully removing understory biomass can restore habitats with historically open understories while reducing the risk of uncharacteristically severe wildfire by reducing fuel loads and removing ladder fuels. Developing markets for these small-diameter trees can create jobs, contribute to local economies, and help pay for restoration. The **USFS's Stewardship Contracting Program** offers opportunities to implement and fund certain habitat restoration and management projects.

Site-by-site decisions must be made on the type and extent of fuel reduction treatments that will be conducted. At some sites, treatments are key to reducing the long-term risk of losing key ecosystem components to uncharacteristically severe fire. However, fuels reduction treatments can impact species and habitat by disturbing soil or eliminating key habitat components, such as canopy cover, hiding cover, snags, large woody debris, or large live trees. These impacts will vary depending on the extent, pattern, and level of fuels reduction treatments. Decisions on fuels reduction treatments must balance the need to maintain these key ecosystem components with management needed to reduce risk of long-term damage to wildlife and habitats from wildfires.

In high priority zones, use active management techniques to reduce surface, understory, and crown fuels. Fuels reduction treatments typically involve mechanical treatments combined with the use of prescribed fire, if appropriate. The most common mechanical treatment is the removal of smaller trees by understory thinning or thinning from below, although other forms of thinning may be employed, as well as mowing and crushing to reduce shrubs and surface fuels. Maintenance treatments will be essential to supporting desired conditions and successional trajectories.

Action 1.4. Using site-appropriate prescriptions, carefully reintroduce natural fire regimes as part of an overall wildfire risk reduction and habitat restoration program in locations where conflicts, such as smoke and safety concerns, can be minimized.

Forested Landscapes

Because of high fuel loads in many areas, the most typical scenario will involve mechanical treatments followed by prescribed fire. A fire management strategy where natural or prescribed fires are allowed to burn under controlled conditions with minimal suppression may be used to achieve risk reductions and restoration goals. A program of active fire suppression, however, will continue to be necessary when fires pose risks to firefighters or threaten local communities, private property, and cultural resources.

Management actions, such as active thinning and prescribed burning, in at-risk green stands will reduce the amount of effort and funding needed for fire suppression in those areas, although stands may need to be treated multiple times to maintain beneficial outcomes. However, the overall goal should be the restoration of conditions where natural fire can perform its historical ecological role across more of the landscape and where compatible with existing land uses. Planning for wildfire risk reduction and habitat restoration should evaluate if it would be feasible, ecologically appropriate, and socially desirable to allow the historical fire regime to return once high fuel loads are addressed.

Unforested Landscapes

Prescribed fire can be a useful tool when tailored to local conditions. However, prescribed fire is not necessarily suitable for all situations. In the **Northern Basin and Range** and **Blue Mountains** ecoregions, low productivity plant communities are extremely slow to recover from prescribed fire and other disturbances. For example, low sagebrush communities have poor, shallow soils and take time (150-300 years) to recover from significant soil disturbance or fire. Wildfires and prescribed fire can both increase dominance of invasive plants, depending on the site conditions.

In the **Klamath Mountains** and **Willamette Valley** ecoregions, prescribed fire poses challenges, such as conflicts with surrounding land use, smoke management and air quality, and public safety. In the **Coast Range** ecoregion, prescribed fire is difficult due to high precipitation and wet conditions. When conditions are dry enough to use prescribed fire in coastal grasslands, there are usually concerns with risk to surrounding forests.

To address these issues, carefully evaluate individual sites to determine if prescribed fire is appropriate. Be particularly cautious in low productivity sites where recovery times are prolonged or in sites with invasive annual grasses. If determined to be ecologically beneficial, reintroduce natural fire regimes using site-appropriate prescriptions and consider conflicts, such as smoke and safety concerns. If prescribed fire is not appropriate or feasible, consider alternative methods that mimic the effects of fire (see Action 1.5 below).

Action 1.5. Use site-appropriate tools, such as mowing, brush removal, tree cutting, and controlled grazing to mimic effects of fire in fire-dependent habitats.

Use multiple site-appropriate tools to maintain open structure habitats. These may include mowing, controlled grazing, hand-removal of encroaching shrubs and trees, or thinning. For all tools, minimize ground disturbance and impacts to native species. Vary treatment types, timing, and spatial distribution to produce a mosaic of different habitats. Use mechanical treatment methods (e.g., chipping, cutting for firewood) to control encroaching conifers. In aspen habitats, reintroducing a disturbance regime may be necessary to reinvigorate aspen reproduction after mechanical removal of conifers. In areas where western junipers are expanding into sagebrush habitats, maintain older juniper trees, which are very important for wildlife.

Action 1.6. Develop tools that evaluate trade-offs between short-term loss of wildlife habitat values and long-term damage to habitat from wildfires and evaluate effects of forest management practices that reduce wildfire risk to wildlife habitat values.

Efforts to reduce wildfire risk and restore habitats need to occur within an adaptive management framework in which actions are monitored and modified in response to results and changing conditions. In some cases, wildlife habitat elements, such as hiding cover, snags, and downed wood will be reduced by fuel reduction activities. However, not taking any action could result in complete habitat loss through severe wildfire. Thus, analytical tools are needed to evaluate and compare the short-term risk of fuel reduction treatments to species and habitats against the long-term risk to species and habitats posed by uncharacteristically severe wildfire. In landscape-scale restoration projects, these tools should also assess connectivity and corridors that allow at-risk wildlife species to move away from disturbed areas, as well as move back into rehabilitated areas. Such tools would assist landowners and land managers in determining appropriate actions for individual sites.

Fire suppression and fuel reduction techniques need to be monitored to determine the short-term impacts on species and habitat, and the long-term effectiveness in reducing the risk of uncharacteristic fire. Furthermore, research is needed to better understand the effects of historical fire regimes, severe wildfire, and fire suppression on wildlife. Also, historical disturbance regimes are not well-understood for all habitat types, so research is needed to determine the historical frequency and severity of disturbance that maintained **Key Habitats**. Formulate management approaches, including use of prescribed fire, accordingly.

Action 1.7. Use herbicides to minimize colonization of invasive winter annuals after wildfire in shrub-steppe communities.

After catastrophic wildfires in sagebrush-dominated communities in drier parts of the state, like the **Northern Basin and Range** ecoregion, herbicides can be used to kill invasive winter annuals (e.g., cheatgrass and medusahead) so they do not dominate the post-fire landscape. This can greatly improve the ability of native grasses and shrubs to re-colonize and establish. Supplemental seeding and/or replanting with native species after large-scale wildfires will further improve the reestablishment of desired species and limit or reduce the spread of invasive plants.

ALTERED WATERWAY AND FLOODPLAIN FUNCTION

From time to time, Oregon's waterways, filled by rain and snowmelt, overflow their banks and spread across the landscape. Minor floods occur relatively frequently and on most Oregon streams at one time or another. Many streams flood once or more each season. Floods on rivers in eastern Oregon are more often the result of spring snowmelt. The central and eastern areas of the state are also subject to summer thunderstorms that drop large amounts of rain in short periods, overwhelming the soil's capacity to absorb the moisture and river systems to transport it, resulting in flash floods. In western Oregon, winter storms and spring rain-on-snow events contribute to seasonal flooding.

The area of land adjacent to the river that absorbs overflow during floods is the river's floodplain. Rivers often carve new courses during floods. Over time, rivers gradually move across the landscape creating oxbows and excavating new channels and alcoves. This makes naturally flowing rivers good habitat for aquatic species and floodplains fertile habitat for terrestrial species.

Many naturally flowing rivers, however, have been modified in a number of ways. Dams alter river dynamics with significant effects on aquatic and terrestrial communities. In addition, rivers have been channelized for a variety of reasons. Rivers have been dredged and deepened to improve their use for transportation, flood control, and irrigation needs, as well as to increase the area available for agriculture. The placement of riprap, levees, and deflectors harden and stabilize banks and redirect river flow in an attempt to prevent localized erosion and channel movement. These structures constrain rivers to a single course, disconnecting them from their floodplains and increasing the erosive potential downstream.

Climate change is also causing impacts to Oregon's hydrology, leading to altered precipitation patterns, reduced snowpack, and increased risks of both floods and droughts. Increased precipitation in late summer and winter will likely increase flooding risks, especially in highly populated ecoregions. Warmer temperatures are causing more precipitation to fall as rain instead of snow, resulting in earlier snowmelt and potentially higher peak flows, as well as reduced summer low flows. This, in turn, affects water supplies for various users, including agriculture, municipal consumption, and aquatic ecosystems.

History of Dams on Oregon's River Systems

Oregon's first dams were built in the late 1800s to supply electricity to cities and water-powered flour mills. Significant dam building took place between the turn of the last century and the 1960s. Many splash dams were built to transport logs from forest to mill, but they were so damaging to streams they were outlawed in 1958. The federal government erected dams to provide irrigation water to farmers. The first of these projects in Oregon (under the 1902 Reclamation Act and managed by the Bureau of Reclamation) was the Klamath Project, a complex of dams and canals that drained extensive wetlands and diverted lake water to irrigate 225,000 acres of former rangeland. The Flood Control Act of 1936 declared that flood prevention was in the public interest and shifted the emphasis to multiple-purpose dams to improve flood control. By 1940, over 70 percent of Oregon's current water storage capacity was in place behind eight Bureau of Reclamation dams.

The U.S. Army Corps of Engineers currently operates roughly 20 dams in Oregon, 11 of them west of the Cascades. Those constructed on the Columbia River (i.e., Bonneville, The Dalles, John Day, and McNary) were built to generate electricity, rather than provide water storage. Today, the greater percentage of dams across the state are operated by cities, local districts, or individual landowners for a variety of purposes, including flood control.

Effects of Modification on River Dynamics, Floodplain Function, and Fish and Wildlife Habitats

The loss of a river or a stream's connection to its floodplain reduces its ability to absorb floodwaters. When small streams and creeks reach flood stage and overflow onto adjacent lands, the pulse of floodwater slows before reaching larger rivers. The speed and severity of modern floods is increasing with the loss of this floodplain "sponge effect". In developed areas, modifications have been made throughout river and stream systems. Paved surfaces significantly limit infiltration into the ground and instead concentrate stormwater into pipes and directly into streams. In rural areas, agricultural ditches move water off the land quickly.

One of the important functions of flooding is to move gravel from uplands to lower sections of the stream. Clean gravel is an essential streambed surface for healthy salmon spawning beds. When water flows through gravel, it can cool and change chemistry, improving conditions for cold-water anadromous species. In modified streams, dams trap gravel and silt and constrain major floods that would normally move gravel downstream.

Channelization can contribute to greater streambank scouring and erosion as loss of stream complexity (e.g., bends, pools, eddies) destabilizes banks and interferes with gravel transport and deposition. Within a floodplain, modified flow can limit channel migration, which in turn limits the creation of off-channel habitat, such as oxbow lakes, backwaters, and sloughs that provide important habitat for SGCN such as the Oregon chub or foothill yellow-legged frog. Side channels and off-channel habitat also provide sheltered settings outside the main river current where young fish and other small aquatic creatures can rest or feed. Since natural river channels are maintained by a dynamic equilibrium between erosion and deposition of gravel and silt, water moving without silt or through straightened channels can cause riverbed and riverbank erosion.

In natural systems, large floods send logs tumbling into mountain streams and topple trees along riverbanks. The force of floodwater moves submerged logs into new locations. These actions rearrange the river habitat, flushing out sediment and setting up new complex structures necessary for healthy aquatic habitat. Removal of wood, and lack of large wood recruitment from the landscape, often leads to channel simplification and a loss of in-stream habitat. Dams temper the force of floodwater, diminishing the power of streams and rivers to move large wood, thus depriving streams of new structure that is important for fish habitat. Channelization removes the complexity of existing stream structure which straightens and speeds flows, thereby depriving streams of potential locations for large wood debris recruitment and retention.

Water temperature cycles are altered by impounding water behind dams with resulting disruption of temperature-dependent life cycles of anadromous fish, wildlife, and their food sources. **<u>Flowing water</u>** in streams is full of nutrients and oxygen. **<u>Riparian vegetation</u>** provides important shade to keep water cool. Water held behind dams warms in the summer sun. The surface temperature rises while cold water sinks, and suspended material settles to the bottom. Phytoplankton, single-celled plants that make up the base of the food chain, proliferate at the top, releasing oxygen. When they die, they sink to the bottom where bacteria consume them and use oxygen. Over the course of the summer, the water at the top of a reservoir is warm and full of oxygen and food. The water at the bottom is cold and low in organic matter and oxygen. This is significant for fish because their life cycles, and those of their food sources, are triggered by temperature. Over time, dammed rivers behave more like lake ecosystems, losing their capacity to support riverine fish species. Dam releases can be controlled to maintain appropriate temperatures for fish, amphibians, and reptiles, but these decisions are made with a variety of other factors to consider like electricity generation and irrigation needs.

Dams and other flood control structures/modifications have also affected river floodplain habitats. Floods that used to occur every 10 years or so now occur every 100 years or more. Former floodplains no longer receive regular deposits of waterborne sediment. Disconnected from their rivers and drained, they no longer provide wetland and seasonally flooded habitats. In addition, annual high-flow events have become “flashy” (e.g., shorter in duration and greater in intensity) in some areas where there has been extensive channelization and loss of floodplain function.

[Spotlight] Beaver Habitat and Beaver Modified Habitat

Beavers are widely distributed across Key Habitats statewide, including Flowing Water & Riparian, Wetlands, and Aspen Woodlands. **Beaver habitat**, or habitat for beaver, is the specific combination of water, food, cover, and space that beaver need to support their survival on the landscape through time. Beaver are semi-aquatic species that require still or slow-moving, perennial water at stable depths for cover, protection from predators, access to food resources, and food storage in the winter. Beavers are slow on land and prefer to forage within 100 feet of their water source. They need sufficient early seral stage stream buffers of deciduous and herbaceous riparian vegetation for food and foraging activities. Beavers are highly territorial and require adequate lateral and longitudinal habitat quality and stability to support their occupancy on the landscape. In rivers and stream networks, one beaver family unit (on average two adults, two sub-adults, and two kits) needs approximately 0.5 to 1.5 linear stream miles for ample space to survive, reproduce, and thrive. **Beaver habitat**, habitat for beaver, supports the building blocks that beaver need to create **beaver-modified habitats**, or habitat by beaver. Habitat limitations for beaver — declining surface water availability, altered floodplain disturbance regimes, conversion and loss of wet meadow and wetland habitats, and altered riparian vegetation communities — are also primary limiting factors for many Species of Greatest Conservation Need.

Beaver are a keystone species that modify and create habitats that can also benefit many of Oregon’s native fish and wildlife. **Beaver-modified habitat**, or habitat by beaver, is the specific conditions beaver create when they alter their terrestrial and aquatic habitat to improve their fitness and survival. These habitat modifications include: denning, damming and ponding water, creating canals or side-channels, importing woody and vegetative materials into flowing water and wetlands, and changing the structure of riparian vegetative communities.

ALTERED WATERWAY AND FLOODPLAIN FUNCTION: GOALS AND ACTIONS

Goal 2. Maintain and restore waterway and floodplain functions, such as groundwater recharge, water quality improvements, natural nutrient and sediment movements, resilient riparian corridors, habitat connectivity, and habitat variation.

Action 2.1. Restore floodplain function by reconnecting rivers and streams to their floodplains, restoring stream channel location and complexity, removing dikes and revetments, allowing seasonal flooding, restoring and maintaining wetland and riparian habitats, and supporting beaver habitat.

Work with local communities, watershed councils, landowners, and other partners to restore and reconnect natural stream channels and floodplains. Explore opportunities for broad-scale floodplain restoration on main rivers and their tributaries. While restoration of entire rivers may not be feasible, seek opportunities to restore critical mainstem or tributary habitats, floodplain function, and critical off-channel habitats adjacent to the main channels. Use sub-basin plans and similar efforts for key information on floodplain issues and opportunities.

Action 2.2. Provide outreach about the ecological benefits of allowing rivers to meander back and forth across the floodplain.

Facilitate discussions within urban and residential communities regarding building or development within the floodplain and riparian areas. Provide outreach about the dynamic, meandering nature of rivers and streams. Allowing rivers to meander back and forth across the floodplain reduces bank erosion and offers ecological benefits for local species. As the **Federal Emergency Management Agency** (FEMA) continues to work with local governments to address floodplain issues and offers tools and resources to help manage floodplain risk while permitting floodplains to function naturally.

Action 2.3. Work with power companies, agencies, irrigation districts, and municipalities to time water releases to replicate natural flood cycles.

Work with power companies and municipalities to develop a schedule of releases timed to replicate natural flood cycles, while continuing to provide essential hydroelectric power and water storage services. Work with the FEMA and other floodplain managers to minimize potential for impacts from new development and redevelopment in the channel migration zone, and to consider ways to maintain or incentivize floodplain protection.

Action 2.4. Identify and restore important off-channel habitats and oxbows cut off by previous channel modification.

While revetments or impact-resistant material (e.g., stone, concrete, sandbags, or wooden piles) applied to a streambank protect riverside property, they also simplify or eliminate the side channels, alcoves, seasonal wetlands, and islands that provide essential complex habitat structure for aquatic species. These are critical areas for fish, such as juvenile salmonids and Oregon chub, amphibians, birds, and reptiles. Reconnect these habitats to rivers where feasible. Use bioengineering instead of riprap on bank-stabilization projects. Update floodplain and channel migration maps, including projected floodways associated with climate change, and integrate them into the land-use planning process.

Action 2.5. Support the use of green infrastructure in place of hard barriers to support stormwater management and respond to flooding concerns.

Green or **natural infrastructure** is a water management strategy that maintains or mimics the natural water cycle. Examples include increasing vegetation cover on roofs, use of permeable surfaces to allow infiltration of water runoff, or planting rain gardens to help reduce and treat water where it falls. Green infrastructure can help maintain floodplain function, manage stormwater, and mediate some of the impacts from climate change. Communities may also benefit from cost-savings, improvements in public safety, and increased opportunities for recreation. Successful examples include the **Clean Water Services Stormwater Program** and the **City of Portland Stormwater Management Program**.

Action 2.6. Remove artificial barriers and infrastructure impacts such as undersized culverts and at-risk structures in the floodplain.

Reduce head-cutting of streams resulting from stormwater discharges by replacing culverts that are not at stream grade, reducing run-off to streams, and maintaining or replanting stream banks and riverbanks with native vegetation. When re-development is planned, explore opportunities to remove structures or pavement from floodplains and restore native vegetation. Coordinate with ODFW Fish Passage on appropriate approvals for structures.

Action 2.7. Support and encourage beaver occupancy and dam-building activity.

Beaver dams can help restore floodplain function, reduce sedimentation, improve water quality and fish habitat, restore wetlands, and improve habitat for many species of birds, amphibians, and other wildlife. Beaver dams can prolong the benefits of off-channel habitats, especially during summer months, and help lessen the impacts of wildfires in riparian areas. Where beavers and beaver dams are present, work with cities, municipalities, and landowners to implement co-existence strategies that reduce the likelihood of beaver damage and maintain beaver on the landscape.

Limiting development adjacent to streams and sloughs, and planting with early floodplain successional plants such as willow, can allow beavers to maintain dams and limit flooding to private property or damage to streamside agriculture. Further outreach and informational materials about the role for beaver in restoration projects may be useful for landowners, land managers, and conservation organizations. For example, see the **Beaver Restoration Guidebook: Working with Beaver to Restore Streams, Wetlands, and Floodplains**, a guidance document produced in collaboration by several federal agencies, including the USFWS, NOAA, USFS, and Portland State University. ODFW also provides guidance on **living with beaver**.

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INVASIVE SPECIES

BACKGROUND

CMP Direct Threats 8.1, 8.2, 8.4

To define “invasive species,” the Oregon State Wildlife Action Plan uses the definition from Oregon Revised Statute 570.755(1): Nonnative organisms that cause economic or environmental harm and are capable of spreading to new areas of the state. ‘Invasive species’ does not include humans, domestic livestock, or non-harmful exotic organisms.

In Oregon, non-native organisms are arriving and thriving, sometimes at the expense of native fish and wildlife, their habitats, and the state’s economy. Invasive species impact all habitats in Oregon, from estuarine systems to high alpine habitats and everywhere in-between. Non-native species can adversely affect native species by various means, including competing for food and space, preying on native species and/or their eggs or young, spreading novel diseases, or producing toxins. Many non-native species have been introduced to Oregon either accidentally or intentionally. While not all non-native species are invasive, some crowd out native plants and animals and become a serious problem. Invasive species are often one of the most significant drivers of native species becoming endangered, and can also lead to secondary impacts that further harm ecosystems such as increased use of pesticides or herbicides.

Invasive Non-native Species

When an invasive species is introduced into a new environment, it leaves behind the natural agents that controlled its population growth in its original home, such as predators, disease, or parasites. Without this control, species can quickly expand, outcompeting and overwhelming native species that may not have evolved the necessary survival strategies to fend off unfamiliar species or diseases.

Invasive non-native species can have many negative consequences for fish, wildlife, and habitat throughout Oregon. Invasive species are one of the leading factors contributing to native species becoming at-risk of extinction in the United States. Invasive species also include disease-causing organisms, such as viruses, bacteria, prions, fungi, protozoans, and internal (roundworms, tapeworms) and external (lice, ticks) parasites that can affect the health of humans, livestock, and pets in addition to fish and wildlife [LINK to SWAP Fish and Wildlife Diseases]. Non-native invasive species can also cause significant economic damage to landowners by degrading land productivity or economic value.

Depending on the species and location, the impacts of invasive species to ecosystems may include:

- disruption of food chain dynamics and direct predation of native species
- alteration of habitat composition through displacement of native vegetation
- increased wildfire risk
- reduced productivity of commercial forestlands, fisheries, farmlands, and rangelands
- modification of soil chemistry
- acceleration of soil erosion
- reduction in water quality
- reduced biodiversity
- increased disease transmission
- novel patterns of habitat succession

Pathways of Introduction

Globalization has increased the rate at which non-native species are introduced to new habitats where they can become invasive: every year, new non-native species are documented in Oregon, bringing with them the threat of ecological and economic damage. There are many different pathways for the introduction and movement of non-native species, including travel, the transport of goods, recreation, or even natural processes like wind or water that can accelerate the movement of invasive species after they arrive. Many of these species are introduced unintentionally by people, often escaping detection until it is too late to control their prolific expansion and devastating effects. Others are released intentionally, including the release of unwanted pets or planting of nonnative vegetation.

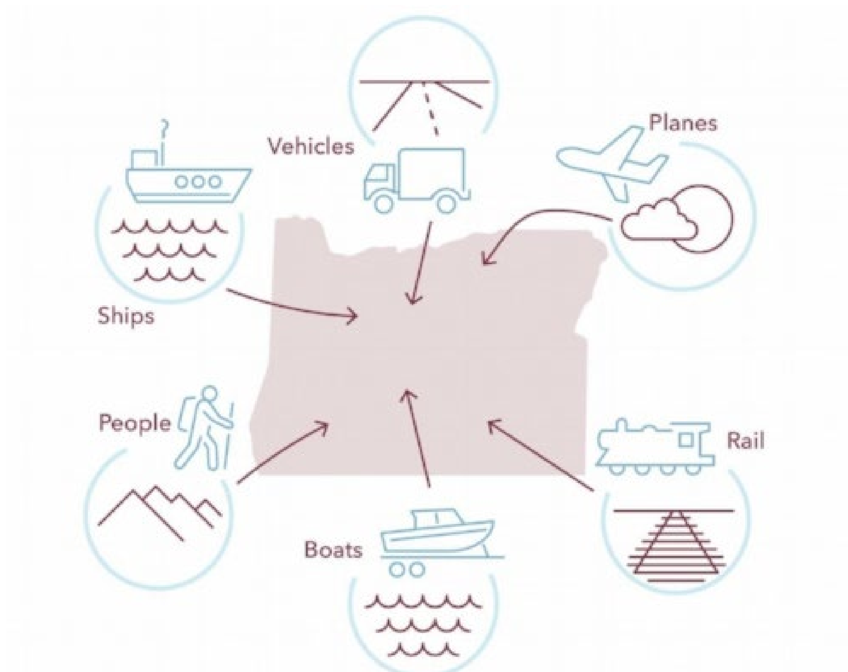

Figure 1. There are many different pathways and vectors for introduction and movement of invasive species, including human activity, transport, and varying environmental systems. Visit the Oregon Invasive Species Council website for further information. Illustration by Studio Clear.

As the pace of globalization and cross-border trade increases, so does the risk of introducing non-native species though unintentional transport via our trade networks. Insects and other stowaways move undetected in agricultural commodities, livestock, wood products, ballast water, and even packing material. An example of this is the emerald ash borer (*Agrilus planipennis*), an exotic beetle that was unintentionally introduced to the United States through wood packing materials or pallets shipped from Asia. After emerging in the US, the emerald ash borer has spread through natural expansion, as well as transportation of infested firewood and nursery stock, and has caused the destruction of tens of millions of ash trees across North America.

Oregon's rivers and lakes are vulnerable to aquatic invasive species, such as the highly invasive zebra mussels (*Dreissena polymorpha*) and quagga mussels (*Dreissena bugensis*). These are invaders from the Ponto-Caspian Sea region and have spread throughout the Great Lakes, Midwest, and the Southwest, and were detected in the Snake River in Idaho in 2023. Zebra and quagga mussels can be unintentionally spread in their adult life stage attached to boat hulls, motors, or trailers, or as larvae in live wells or standing water found in boat motors.

Another vector of invasion for these mussels, as well as other aquatic species, is the live fish trade. In 2021 and again in 2024 the highly invasive zebra mussel was discovered on shipments of moss balls to aquarium stores in the Pacific Northwest and subsequently to aquarium owners. New infestations of zebra mussels could easily emerge as aquarium owners perform routine water exchanges while cleaning their tanks, unknowingly introducing mussels into water infrastructure systems in our communities.

People have also intentionally released new species into the environment, many of which have become invasive. People depend on a variety of non-native plants for food, livestock feed, and ornamental, medicinal, or other uses. While most of these plants have little environmental effect, some like the Scotch broom (*Cytisus scoparius*), Japanese knotweed (*Reynoutria japonica*), and Armenian (Himalayan) blackberry (*Rubus armeniacus*) can escape into natural areas. When this happens, they can crowd out native plant communities. Non-native fish (both legal introductions and illegal releases), American bullfrogs (*Lithobates catesbeianus*), feral swine, and several non-native species of birds have been released to provide new fishing and hunting opportunities; these species can devastate native wildlife populations. Nutria (*Myocastor coypus*), which cause tremendous damage in agricultural areas, were released in Oregon after failed attempts at raising them commercially for fur. People sometimes release unwanted pets, including red-eared sliders or snapping turtles, into the wild and aquarium fish into local streams and ponds. In many cases, these releases are illegal.

Once introduced, natural pathways may help to spread invasive species, especially plants whose seeds or parts are easily dispersed by wind, water, and wildlife. Certain land management practices can serve as conduits or create conditions that favor the spread of invasive organisms. Regardless of the pathway or practice implicated in the problem, experts believe that environmental disturbance is often a precursor to invasion by non-native plants. Invasive non-native species are typically highly adaptable and competitive, taking advantage of the available space, water, and sunlight in disturbed areas. Following introduction and successful establishment, these species may increase their dominance and distribution until they reach the environmental and geographic limits of their expansion. Populations of invasive species may stabilize eventually but often not before inflicting significant environmental and economic damage.

Although introductions of invasive species to Oregon may be inevitable, preventing them from arriving in the first place is the most cost-effective way of controlling invasive species and is in everyone’s best interest.

NON-NATIVE INVASIVE SPECIES IN OREGON

The study of invasive species is a fast-moving field, and keeping track of new invaders is a collaborative effort. Oregon Noxious Weeds Control, Oregon Insect Pest Prevention and Management, Oregon Department of Fish and Wildlife, Oregon Aquatic Invasive Species Prevention Program, and others share responsibility for oversight, regulations, and/or programs related to invasive species in Oregon. Oregon's Invasive Species Council maintains an up-to-date list (including plants; vertebrates; invertebrates; and microorganisms, fungi, and diseases) of relevant invasive species to Oregon on **Oregon's Invasive Species Information Hub**, providing information on the species as well as the Key Habitats and Ecoregions in Oregon they may threaten most.

Each year, new exotic species are documented in Oregon or near our borders. For example, the Oregon Department of Agriculture recognizes an average of 10 new exotic terrestrial invertebrate species annually. However, not all these new arrivals establish self-sustaining populations, and of those not all of them become invasive. Table 1 highlights some of the most impactful invasive species relevant to Oregon, including well-established species (like the American bullfrog), and species on Oregon's borders (like the quagga mussel). From outcompeting native species for resources to directly harming vulnerable populations, these invaders can alter water quality, reduce biodiversity, and displace native species. Understanding these impacts can help inform management and protection of our natural environments from further degradation.

Table 1. Examples of invasive species that can have far-reaching impacts to Oregon's native fish, wildlife, and their habitats once established. For a regularly updated list of non-native invasive species in Oregon including plants, vertebrates, invertebrates, microorganisms, fungi, and disease, see Oregon's Invasive Species Information Hub.

Examples of invasive species and their impacts to Oregon's ecosystems		
Common Name	**Scientific Name**	**Impacts**
Zebra mussel	*Dreissena polymorpha*	Quagga and zebra mussel invasions are known to have catastrophic impacts to native systems and infrastructures in North America. These species can kill native freshwater mussels by attaching to their shells or through outcompeting them for resources. These species are filter feeders and disrupt native food webs by removing microorganisms and altering water chemistry, leading to degraded water quality and algal blooms. They can also displace native species in lake and river bottoms, collapsing the populations of amphipods that native fish rely on. Invading mussels can populate rapidly, clogging infrastructure by attaching to manmade structures such as pumps, pipes, and screens, causing damage to hydroelectric turbines and intake structures for drinking water and irrigation. Golden mussels have impacts similar to quagga and zebra mussels and have recently been detected in North America for the first time.
Quagga mussel	*Dreissena rostriformis bugensis*	
Golden mussel	*Limnoperna fortunei*	
Rusty crayfish	*Orconectes rusticus*	Non-native crayfish species (including the rusty, ringed, and red swamp crayfish) are larger and more aggressive and can outcompete Oregon's native

Ringed crayfish	*Orconectes neglectus*	signal crayfish (*Pacifastacus leniusculus*) for food and resources, which can lead to declines in native species populations. Red swamp crayfish in particular can be destructive to native habitats and are highly invasive once introduced. Red swamp crayfish have a broad diet including plants, tadpoles, snails, other crayfish, and insect and amphibian larvae. Burrowing activities of these crayfish can cause bank destabilization and increased water turbidity.
Red swamp crayfish	*Procambarus clarkii*	
Mute swan	*Cygnus olor*	Mute swans, which can be distinguished from native swan species by their orange bill with prominent black knob near the forehead, can devastate native wetland habitats. Impacts include destructive feeding habits that can dramatically reduce submerged aquatic vegetation communities, disruption of the food web, aggressive behavior that may prevent native bird species from nesting, and impacts to migrating waterfowl. Further, mute swan presence can increase water turbidity, increase soil erosion, and reduce biodiversity. Adult mute swans are large and highly territorial and may harm or harass native species.
American bullfrog	*Lithobates catesbeianus*	American bullfrogs are native to eastern North America. Introduced in the 1900s, they can now be found throughout Oregon but are most common west of the Cascades. American bullfrogs are linked to the decline of native species, particularly amphibians, as they can outcompete native species for food and space, in addition to preying on their eggs and young. Additionally, bullfrogs can spread disease to native species that can devastate vulnerable populations. Among other species, American bullfrogs are known to directly impact Oregon spotted frogs (a threatened species) and northwestern pond turtles (proposed threatened) through predation and competition for resources.
Red-eared slider	*Trachemys scripta elegans*	Common snapping turtles are much larger than the native turtle species found in Oregon and may displace native turtles from their nesting and cover habitat, outcompete native species for food, and prey on native turtle hatchlings. Red-eared sliders compete with native turtle species for resources, including food, nesting, basking, and cover habitat. Non-native turtles can transmit parasites and diseases like shell disease to native turtle populations that do not have immunity. These species are often kept as pets, and illegal releases to the wild can result in reproducing populations that directly impact native turtle populations.
Common snapping turtle	*Chelydra serpentina*	
Green crab	*Carcinus maenas*	The green crab, an invasive species, can disrupt native coastal habitats by destroying eelgrass beds and salt marsh plants, which provide important habitat for larval fish, invertebrates, shorebirds, and other species and maintain ecosystem functions. They directly compete with native crab species for food and habitat and can damage fisheries. The green crab is highly invasive, with few predators, and is an aggressive predator with the potential to significantly alter any ecosystem it invades.

Feral swine	*Sus scrofa*	Feral swine, or wild pigs, cause significant harm to native wildlife and ecosystems. These animals cause direct impacts to sensitive species by preying on nests, eggs, and young of ground-nesting birds and reptiles, and additionally will consume small mammals, reptiles, amphibians and insects. Feral swine directly compete with native species for resources, and their presence can displace other species. Additionally, they can carry disease and parasites that can infect native wildlife. The most damaging impact feral swine have is through habitat destruction: their natural behaviors such as rooting (digging in the soil), wallowing, and trampling vegetation has far-reaching impacts. Through these behaviors feral swine can act as ecosystem engineers, degrading native habitat structure. Feral swine activity can alter water quality and runoff in wetlands, change plant composition and distribution, and reduce tree diversity by damaging young trees and plant life.

[Spotlight] Invasive Species in the Nearshore

Non-native and invasive species are a concern for Oregon’s estuaries and nearshore waters. Non-native species arrive in a variety of ways including release of animals kept as pets, escapes from aquaculture facilities, intentional introduction, hitchhiking on boats or recreational equipment, seafood packing and disposal, and perhaps most importantly, ballast water. International shipping (including its ballast water component), followed by aquaculture, have been identified as the two greatest sources of introductions of marine and estuarine invasive species worldwide. Ship ballast water is known to carry viable organisms from one body of water to another, and it is estimated that over two-thirds of recent species introductions in marine and coastal areas are likely due to this ship-borne vector.

One well-documented invasion in Oregon is the Griffen’s isopod (*Orthione griffenis*), native to Asia and likely introduced via ship ballast water during the 1980s. This parasitic isopod can draw enough blood from the native blue mud shrimp (*Upogebia pugettensis*) to prevent it from reproducing. The introduction of this parasite has been linked to substantial population declines of blue mud shrimp in many Pacific Northwest estuaries.

Another well-documented invasion is the European green crab (*Carcinus maenas*), native to the northeast Atlantic and Baltic Sea coasts, which was first seen in San Francisco Bay in 1989. European green crab larvae can survive for up to 80 days in coastal waters and then return to adjacent bays and estuaries to settle. The expansion of European green crab from San Francisco Bay likely occurred on coastal currents south to Monterey Bay and northward to Humboldt Bay, California. The spread to Coos Bay and Yaquina Bay, Oregon, Willapa Bay and Grays Harbor, Washington, and the west coast of Vancouver Island occurred following the strong El Niño of 1997/1998. The expansion of European green crab up the east coast of the U.S. to Maine occurred over an approximately 120-year period, culminating in the collapse of the soft-shell clam industry in Maine. European green crab could possibly threaten Dungeness crab, oyster and clam fisheries and aquaculture operations in the Pacific Northwest.

Estuaries are especially susceptible to adverse impacts from invasive plants and animals. Coastal ocean conditions are critical determinants of biological invasions of estuaries, but the processes and possible management strategies for limiting ocean dispersal of invasive species are unknown. In estuaries, invasive plants can alter water circulation and sediment patterns. For example, common cordgrass (*Spartina anglica*), which has been documented in two Oregon estuaries and is well-established in Washington and California, reduces mud flat habitats, disrupts nutrient flows, displaces native plants and animals, and traps sediments, which changes the beach profile and water circulation. Three other cordgrass species have invaded the Pacific coast and could potentially pose a threat to estuaries.

Within the nearshore ecoregion, an effort by conservation partners in Oregon was initiated in 2012 to assess existing or potential threats to marine and estuarine ecosystems. ODFW developed a list of non-native species known to occur in the nearshore waters of Oregon and neighboring states, in consultation with Oregon State University (OSU), the Environmental Protection Agency (EPA) Western Fisheries Research Center, USGS, and Williams College. This information was last updated in 2015. At that time, more than 200 non-native species had been identified in Oregon marine and estuarine waters, of which 14 were classified as invasive (see **Appendix – Nearshore Species**).

ASSESSING RISK

Evaluating the potential danger associated with the introduction of a new species is sometimes very difficult. Variables such as how the species will respond in a new environment, or which species might arrive within the state and when, are oftentimes unknown. Many invasive species, especially those that are aquatic (e.g., invasive tunicates), can be difficult to detect before they pose a large threat. Once invasive species are established, controlling them can be difficult, expensive, and in some cases, impossible. Priority must be placed on preventing the introduction of new species. Not every new non-native species is equally threatening, so gauging the level of risk and responding accordingly is important to avoid misallocating limited resources on species of low ecological or economic concern.

[Spotlight] Invaders on the Horizon

There are many invasive species in North America that are not yet established in Oregon but will likely arrive without interventions. Cross-jurisdictional partnerships are foundational to preventing the spread of these species to Oregon that may have devastating impacts to native ecosystems and agriculture alike.

Table 2. Examples of species with potential to arrive and become established in Oregon, including anticipated impacts to ecosystems and communities.

Common Name	Scientific Name	Anticipated impacts of future invasion
Swede midge	*Contarinia nasturtii*	The swede midge (*Contarinia nasturtii*) was first detected in the United States in 2004. This species can have devastating impacts on native brassicas (i.e., plants in the mustard family) as well as agriculturally important crops like canola and broccoli. The swede midge attacks the apical meristem of plants, preventing flowering. The spread of the swede midge can result in increased pesticide use and poses a threat to specialized native pollinators of brassicas such as *Andrena winnemuccana,* a critically imperiled bee.
Rat lungworm	*Angiostrongylus spp.*	Rat lungworms are nematodes of the genus *Angiostrongylus*, particularly *A. cantonensis*. These nematodes parasitize mollusks (mostly terrestrial species, but also aquatic) and earthworms, and can infect and harm many vertebrates including mammals, birds, and reptiles. *A. cantonensis* invades brain tissues of non-rodent vertebrate hosts. It is most likely moving with slugs on live plants. It was first found in Louisiana in the 1980s and has now spread throughout much of the southeastern United States, with cases as far as west Utah and southern California.
Lablab bug	*Megacopta cribaria*	A single specimen of the lablab bug (*Megacopta cribraria*), also known as bean plataspid or kudzu bug, was found in Oregon in 2024. This pest of legumes was first found in Georgia in 2009 and has since spread throughout the southeastern US. If established, this species will have impacts to native ecosystems by causing increased pesticide use, and may also harm native legumes, which, in turn can harm native specialists such as the bee *Calliopsis barri*.

Longhorned tick	*Haemaphysalis longicornis*	The longhorned tick (*Haemaphysalis longicornis*) is a tick native to Asia first found in the United States in 2017. It has spread quickly and is now as far west as Missouri. It attacks both mammal and bird species, and populations of this tick can become very large. In addition, the longhorned tick can transmit several diseases to humans, wildlife, and livestock. The longhorned tick was found to be spreading a novel disease to North America, theileria, to cattle in Virginia in 2021.

Non-native Game Fish

Many non-native fish species are legislatively defined as game fish in Oregon. These species include but are not limited to bass, walleye, sunfish, crappie, yellow perch, bullhead/catfish, striped bass, American shad, lake trout, brook trout, and brown trout. ODFW provides angling opportunities for some of these species by transplanting fish from one waterbody to another and stocking hatchery-produced fish; this is done in locations where the assessment of risk indicates that impacts to native fish and wildlife are expected to be minimal. Despite best efforts, however, these same fish can still pose threats to native species, through direct competition, predation, or impacts to habitat.

In some situations, these non-native fish species move to new locations naturally after environmental or habitat disturbance events or are moved by people either unintentionally or illegally. When this happens, they can become naturally self-sustaining, negatively impacting Oregon’s native species and habitats through competition, predation, introduction or transmission of pathogens, and hybridization. The magnitude of impact of each of these factors can vary significantly across species or locations and habitat conditions. In recent years, smallmouth bass were illegally introduced into the Coquille River. The result of this illegal introduction led to the drastic decline of native wild fall chinook salmon due to predation. Impacts of non-native trout on native trout also occur. Brook trout occupy similar habitats as native bull trout, and they can cause impacts through competition for resources and genetic introgression (i.e., hybridization).

Non-native game fish occur in many aquatic systems throughout the state. ODFW seeks to prevent the uncontrolled spread of these species and will evaluate situations on a case-by-case basis. Management of these species may differ depending on type of water body (i.e., natural rivers, streams, and lakes or man-made ponds, lakes, and reservoirs), how established a population has become, how altered the water body is, and the spatial and temporal overlap with native species. Management approaches for non-native game fish across these different conditions may range from a) assuring natural habitat conducive to native species is protected and restored, b) actively avoiding establishment and b) actively removing and limiting further expansion c) researching impacts to native species and d) maintaining, improving, or establishing recreational opportunities. For example, in response to an illegal introduction of a non-native game fish species into a river, stream, lake, or reservoir, the Department will attempt to eradicate or limit expansion of the species if it is able and feasible to do so.

Data are needed to better describe non-native game fish populations, distribution, and impacts to native species in the state to inform management decisions. Efforts are increasing to monitor the distribution of non-native game fish species as well as study their impacts on native species.

BUILDING ON CURRENT PLANNING EFFORTS

Several planning efforts are underway to protect Oregon from biological invaders. State statutes or **agency administrative rules** are in place to prohibit the unauthorized entry of undesirable invasive species. Together, the following plans and regulations provide a foundation for addressing invasive species and put the issue into clearer context for this Action Plan:

- **Oregon Invasive Species Council Action Plan**
- **Aquatic Invasive Species Prevention Program**
- **Oregon Noxious Weed Strategic Plan (ODA)**
- **Oregon Aquatic Nuisance Species Management Plan (Portland State University)**
- **Oregon Dreissenid Mussel Rapid Response Plan**
- **Columbia River Basin Interagency Invasive Species Response Plan**

Other ongoing efforts provide information that would be helpful in addressing invasive species. For example, the **USFS Forest Inventory and Analysis Program** uses remote sensing imagery or aerial photography to classify land into forest or non-forest. Permanently established field plots are distributed across the landscape, and 10 percent of these plots are visited each year to collect forest ecosystem data. A subset of these plots are sampled yearly to measure forest ecosystem function, condition, and health, including measurements of native and non-native plants, which can provide information about the spread of invasive species.

Meeting the Challenge: A Framework for Action

Invasive species can be effectively managed and their potential ecological and economic impacts mitigated if the right precautions and steps are taken with a collaborative network of partners. To be effective in managing invasive species, states, counties, private landowners, and public landowners can use this framework of management approaches, adapted from **National Invasive Species Council** guidance documents, to prioritize efforts to safeguard species, habitats, and working landscapes against invading organisms.

The approaches need to be implemented at different spatial scales and across all jurisdictional and ownership boundaries. For example, monitoring can assist with site-specific management decisions. Weed infestations on federally managed land and on adjacent private property are more effectively controlled when federal land managers and private landowners join forces at the landscape level, across ownership boundaries. Reporting these data to a central database is also important for tracking changes in populations and distributions across the state.

Table 3. Management approaches to reduce the impacts of invasive species

Management Approach	Objective
Prevention	Preventing new species introductions is a top priority and the most cost-effective approach to protecting native species, ecosystems, and productivity of the land from invasive species.
Education	Inform the public about the impacts and costs of invasions and methods of prevention.
Risk Assessment	Defining the level of concern and risk associated with new introductions through an assessment process will help to identify the worst invaders and highest management priorities.
Monitoring	The importance of continual surveying cannot be overestimated when looking for first-time infestations of undesirable non-native species or evaluating efforts to control existing occurrences.
Early Detection	Early discovery of infestations of previously undocumented non-native species is critical to controlling their spread and achieving complete eradication.
Rapid Response	Immediate treatment of new, isolated infestations will maximize eradication success and decrease the likelihood of populations expanding beyond the initial area of introduction.

Management Approach	Objective
Containment	Preventing invasive species from 'hitchhiking' via vulnerable pathways will slow the advance of well-established invasive species into unaffected areas. Some invasive species are tolerable if infestations can be contained, and their impacts minimized.
Restoration	A system-wide approach to treating invasive species should consider habitat restoration as part of the ecological healing process. Helping native species and ecosystems recover is an important step following the removal of harmful species.
Adaptive Management	Land managers or landowners should change course on management prescriptions if treatments are not working. Monitoring the results of control actions is an important part of this process.

GOALS AND ACTIONS

Goal 1: Prevent new introductions of non-native species with high potential to become invasive

Action 1.1 Increase public awareness and understanding of invasive species, their impacts, and methods for preventing new introductions through education.

The Oregon Invasive Species Council (Council) coordinates statewide efforts to prevent biological invasions and seeks to mitigate the ecological, economic, and human health impacts of invasive species. Informed landowners, land managers, public officials, and the public can take action to further the Council's goals. Businesses, landowners, anglers, hunters, Oregon residents, and visitors should be reminded of the dangers posed by invasive species through targeted outreach and education. People can greatly reduce the accidental introduction or spread of these organisms into and within Oregon if they know what precautions to take.

State, federal, and tribal agencies and NGOs can work with the Council to promote and raise public awareness of programs to reduce or eliminate the risk of introducing invasive species. For example, **ODA's Noxious Weed Program** provides statewide leadership for coordination and management of state-listed noxious weeds, and **ODFW's Wildlife Integrity Program** regulates the importation, possession, and transportation of non-native wildlife species. Encouraging Oregonians to report sightings of invaders is also important and can be key to the detection, control, and elimination of an invasive species.

Action 1.2 Expand collaborative efforts to prevent the introduction of new invasive non-native species.

The cost and difficulty of managing invasive non-native species increases substantially once a species has established self-sustaining populations. Once established and widespread, invasive species are virtually impossible to eliminate, and control costs can become prohibitive. Therefore, every effort should be made to prevent first-time introductions of invasive species from becoming established in Oregon. By their very nature, however, state borders are porous and vulnerable to the entry of non-native organisms. A significant challenge is developing and implementing effective prevention strategies based on the best available research on where and how new and invasive organisms are likely to enter Oregon.

One example of an effort to prevent the introduction of invasive species is the **watercraft inspection program** for aquatic invasive species (AIS). Inspection stations are located at entry points on major highways along the Oregon's borders. Personnel at these stations inspect watercraft for AIS and if any are found, the watercraft is decontaminated on the spot.

Action 1.3 Strengthen early detection and rapid response plans to facilitate swift containment of new introductions and increase resources, including funding, available to support prevention and rapid response.

Early detection and rapid response are two of the most critical components of effective invasive species management, and resources are needed to ensure that potential infestations are identified early and eradicated before they can establish self-sustaining populations.

The potential dangers of new invasions to forestlands, agricultural and range lands, natural areas, and fish and wildlife should be determined as early as possible so that farmers, ranchers, fish and wildlife managers, and conservationists can be forewarned and better prepared. Teams composed of experts are needed to determine the likely impacts of newly discovered invasive species, predict the spread of new infestations, and decide which steps should be taken to alert the public. Information sharing among a diversity of collaborators and across political boundaries can help make early detection more practical, feasible, and cost effective.

Rapid response plans need to be tested, refined, and practiced before implementing control efforts on a new infestation. Conducting exercises that simulate an infestation can promote better cooperation between government agencies and private organizations and produce more effective and successful eradication efforts for newly detected species. Coordinating with other states that have already faced invasive species removal efforts is also recommended, allowing for the sharing of best practices, lessons learned, and resources to help improve preparedness and response strategies. This proactive collaboration can help mitigate the costs, time, and uncertainty of managing invasive species before they become established in Oregon.

Elected officials, industries, and the conservation community must work together to identify public and private funding to support the efforts of the Invasive Species Council and its partner agencies to develop effective prevention measures. This investment will help protect the economic and ecological interests of all Oregonians, as well as protect Species of Greatest Conservation Need and Key Habitats from the impacts of harmful invaders.

Goal 2: Reduce the scale and spread of priority invasive species infestations when they occur

Action 2.1 Evaluate the ecological impact of individual invasive species and management approaches for priority invasive species.

Assess the scale of the impacts of each invasive species by analyzing current distribution and abundance, trends in distribution and abundance, and difficulty of eradication or management. Working closely with appropriate entities in neighboring states, including Washington, Idaho, Nevada, and California can help to inform prevention efforts and early detection rapid response. This information can be used to determine the best management approaches for individual invasive species and to prioritize invasive species most in need of control efforts. Current and potential partners include The Nature Conservancy, Oregon Biodiversity Information Center, Soil and Water Conservation Districts (SWCDs), Oregon Invasive Species Council, county weed boards, federal land management agencies, ODA, and others.

Action 2.2 Focus on eradication of invasive species in Key Habitats and other high priority areas where there is a clear threat to ecosystems and a high probability of success.

Some invasive species have spread to the point where it would be impractical or impossible to eliminate them from Oregon. Yet some of these established invasive species have significant negative impacts on at-risk species and habitats and can be contained at the local level. In these situations, control efforts should be focused on those invasive species that are limiting factors for Species of Greatest Conservation Need or Key Habitats, particularly within Conservation Opportunity Areas or **Priority Wildlife Connectivity Areas**. Other priorities may include controlling invasive species that disrupt ecological function or impact vulnerable, commercially valuable lands, such as rangeland, farmland, and timberland.

Local eradication of invasive species near high priority habitats and lands should be emphasized where practical, with the ultimate goal of restoring these lands to their full ecological or utilitarian potential. Controlling established invasive species often requires long-term commitment. If funding dissipates out or management priorities change, invasive species can quickly return. Restoration activities can repair habitats degraded by invasive species and may be necessary if aquatic or terrestrial ecosystems are too damaged to recover on their own. Restoration may be the best prescription for inoculating native plant communities against invasive plants, as ecosystems are more resilient to invasion when they are healthy and functioning well. Entities involved in invasive species management should encourage landowners to consider ecologically based restoration as part of any plan to manage invasive species.

Private landowners are increasingly partnering with watershed councils, ODFW, SWCDs, ODA, and federal land management agencies to manage invasive species across property lines. Such broad-scale efforts need to continue and be expanded.

Goal 3: Increase research and data collection efforts on the impacts of invasive species on Species of Greatest Conservation Need and Key Habitats

Action 3.1. Expand research on invasive species ecology and impacts to Species of Greatest Conservation Need and Key Habitats.

Understanding the biology and behavior of invasive species is key to predicting how they will spread, the kinds of threats they pose to native species, and how they interact with their environment. Limited information is available describing direct and indirect impacts of non-native and invasive species on Species of Greatest Conservation Need and Key Habitats. This information is critical for effective management of invasive species and prioritization of management actions. Expanding research on invasive species ecology and their impacts to species and habitats through partnerships can inform effective management and conservation.

Action 3.2 Expand and enhance data collection and sharing to better track the location and severity of priority invasive species infestations.

A number of local, state, and federal agencies, tribes, and private organizations independently gather data on invasive plants, animals, and pathogens in Oregon, but the information is decentralized and often not integrated for analysis. Oregon lacks a comprehensive, coordinated, and centralized system for gathering and maintaining data on the location of non-native species on private and public lands. Efforts to institute a reporting system have also been hampered, in part, because of landowner privacy concerns. Landowners may not report invasive species on their property due to apprehension that disclosure of infestations may lower property values or that they may be held responsible for treatment costs.

There is a critical need to improve the integration and standardization of data on invasive species derived from independent monitoring efforts. Using existing data housed by the ODFW, the Institute for Natural Resources, and other partners, a multi-partner, spatially explicit database and mapping system of non-native plants, animals, and diseases could be developed. The data could be used to track changes and trends in invasive populations, better anticipate the spread of invasive organisms within the state, identify vectors or points of entry and high-risk environments for invasion, and evaluate the success of management actions. Voluntary reporting by private landowners should be encouraged by providing confidentiality, nondisclosure of sensitive information, and free technical assistance on control methods.

Web-based information portals are an important tool for invasive data reporting and sharing. **iMap Invasives** is an online tool that allows users to report invasive species findings, and provides information on invasive species distribution, treatment efforts and effectiveness, and areas where invasive species were searched for but were not found. The **Oregon Invasive Species Council** also has an online reporting and sharing tool. iNaturalist, a community based online species identification system and occurrence recording tool, is another resource that can enhance verifiable data collection from the public.

Action 3.3 Investigate innovative methods to reduce invasive species populations, and share this information broadly.

To improve the effectiveness of invasive species management strategies, research is needed to identify and test new or refined control methods. This could include a combination of physical, chemical, biological, and ecological approaches tailored to specific invasive species and ecosystems.

Stewards of natural habitats need to know how to remove invasive organisms that lower the productivity and value of land, alter ecosystem processes, and threaten native species. They also need to know what level of investment is appropriate, and which techniques are most suitable for each respective situation. Throughout Oregon, people are using a variety of methods to control individual invasive species with varying degrees of success.

Multiple site-appropriate control mechanisms (e.g., mechanical, chemical, and biological) should be evaluated to control individual invasive species. Increased coordination and communication are needed between researchers, agencies, tribes, watershed councils, county weed boards, and private landowners regarding what control methods work and under what conditions. Outreach materials should be developed to assist landowners and land managers in choosing the most appropriate techniques and how to best apply those techniques to their sites.

Currently, there is no known effective way to control some widespread invasive plants, such as cheatgrass (*Bromus tectorum*), medusahead (*Taeniatherum caput-medusae*), and false brome (*Brachypodium sylvaticum).* Research efforts to address these and other invasive species need to be supported and expanded.

ADDITIONAL RESOURCES

- Oregon Invasive Species Council
- National Invasive Species Council
- ODFW Invasive Species Resources
- Western Basin Dreissenid Incident Response Toolkit
- ODFW Prohibited and Controlled Fish, Mollusks, and Crustaceans
- Oregon Administrative Rule 635-007-0620
- ODA Insect Pest Prevention and Management
- Global Invasive Species Database
- USFWS Invasive Species
- USGS Nonindigenous Aquatic Species
- Oregon DEQ Ballast Water and Invasive Species
- BLM Oregon Invasive Species
- BLM Oregon Wild Horse Program
- 100th Meridian Initiative
- Oregon State University: Pacific Northwest Nursery Integrated Pest Management
- Oregon Sea Grant: Invasive Species
- Squeal on Pigs National Hotline
- Prohibited Species Import Rules
- OREGON NOXIOUS WEED PROFILES

[SPOTLIGHT] Invasive Quagga Mussels Detected In Snake River

In September of 2023, the Idaho State Department of Agriculture (ISDA) confirmed the presence of multiple quagga mussel life stages in the Mid-Snake River. The discovery of quagga mussels in the Snake River marked the first time a rapid response plan had been put into action for quagga mussels in Idaho.

ISDA has closely monitored the Snake River since the initial detections, taking more than 300 samples in the affected area throughout 2024. In September of 2024, ISDA again confirmed the detection of a small number of quagga mussels in the Twin Falls area of the Snake River. As of 2025, sample results show a decreased quagga mussel presence in the affected stretch of river since pre-treatment in 2023.

Treatment and ongoing monitoring plans are underway and updates regarding this effort can be found at ***Snake River Quagga Overview — Invasive Species of Idaho***

LAND USE CHANGES

CMP DIRECT THREATS 1, 2, 3, 4

BACKGROUND ON OREGON'S STATEWIDE LAND USE PLANNING PROGRAM

Prior to the 1960s, population growth was not broadly perceived as a concern in Oregon. Between 1940 and 1970, however, Oregon's population grew by 109 percent. Subdivisions sprouted next to farms in the Willamette Valley and Oregonians saw their pastoral landscape threatened by sprawl. Governor Tom McCall and farmer-turned-senator Hector MacPherson collaborated on **Senate Bill 100** (SB 100), which created Oregon's **land use planning program** in 1973. In May 2023, Oregon celebrated 50 years of the land use program, which highlighted that proactive land use planning can provide more certainty to landowners and developers and can strategically protect natural resources and working lands.

The Statewide Land Use Planning Program has been charged by the legislature to manage urban growth and protect natural and working lands, including coastal, estuarine and ocean resources. The Oregon Department of Land Conservation and Development (DLCD) is the state agency responsible for administering the statewide land use planning program, as well as ensuring local governments carry out the intent of the land use program in local planning and permitting. DLCD is guided by the Land Conservation and Development Commission (LCDC). While LCDC and DLCD have the statutory and administrative authority regarding the planning program, the program was established to preserve the principle of local responsibility or control of land-use decisions.

Oregon's land use program is a partnership between local governments and state agencies, and local governments retain significant discretion as to how they implement the program through local comprehensive plans and implementation of land use ordinances. If local governments do not consider fish and wildlife habitat in local land use decisions, these resources will go unprotected, especially for those habitats that are not overseen by state agencies or other land use review processes. For example, the **Oregon Department of State Lands** regulates wetlands and waterways, but they do not regulate the riparian buffers; those are regulated by local governments through one of the Statewide Planning Goals.

Oregon's Statewide Planning Program and **19 Statewide Planning Goals** detail the state's policies on land use and related topics, such as citizen involvement, urbanization, housing, working lands and natural resources. Most goals are accompanied by guidelines, which are suggestions about how a goal may be applied, although guidelines are not mandatory.

One of the program's 19 goals is **Statewide Planning Goal 5**. Unlike some of the more prescriptive goals, Goal 5 is more of a process goal, requiring decisionmakers to consider resource values rather than mandating their protection. When Oregon's Statewide Land Use Planning Program was created, Goal 5 required local governments to adopt programs to protect natural resources, and conserve scenic, historic, and open space resources. This includes minerals and aggregates, historic and cultural resources, scenic waterways, open space, natural areas, energy resources, groundwater, wetlands, fish and wildlife habitat, and riparian corridors. The Goal 5 administrative rule also requires that local governments within a Metropolitan Service District (Metro) identify regional resources within Metro area cities and counties. For example, **Portland Metro** adopted Title 13 (Nature in Neighborhoods) of the **Urban Growth Management Functional plan,** which was acknowledged by DLCD as complying with Goals 5 and 6. **Title 13** established requirements to protect, restore and conserve Metro's significant riparian corridors and wildlife habitat resources.

There are six Goal 5 resource categories, and each category has separate state rules. Other than the **DLCD Goal 5 rule for Greater Sage-Grouse**, which defines significant sage-grouse habitat and directs counties to review applications for development permits using avoidance and **mitigation criteria identified by ODFW**, local governments make the determination on what fish and wildlife habitat resources they want to identify as significant to protect through their Goal 5 program.

The intent of the planning program and Goal 5 was that local governments would periodically review their comprehensive plans and inventories to adapt to changes. Goal 5 was meant to be proactive, wherein the best available data on habitat resources would be evaluated during 5-year reviews. However, in 2007, the legislature enacted a bill that revised the scope of periodic review to include only those cities with a population greater than 10,000. This means the focus of long-range planning is weighted toward meeting development objectives, rather than conservation goals. As a result, most fish and wildlife habitat protected through Goal 5 has not been updated since the 1980s, and local decisions are not incorporating the best available data for fish and wildlife resources. For example, **oak habitats** in the **Willamette Valley** often get converted as a result of rural residential development or wineries because this Key Habitat is not part of a local government's Goal 5 program. Developing and maintaining close partnerships with local government and encouraging Goal 5 inventory updates will be crucial to ensuring that impacts to fish and wildlife habitat related to land development actions will be considered for future land use planning.

The Statewide Planning Goals includes four coastal goals, **Goals 16-19,** which provide a foundation for planning efforts that consider the impacts of development actions, as well as the uncertainties with climate change, on fish and wildlife resources in estuaries, shorelands, and beaches and dunes. In Oregon's coastal zone, the DLCD administers the **Oregon Coastal Management Program** for the National Coastal Zone Management Act (CZMA). As part of this program, DLCD determines **federal consistency** to ensure that land use decisions are consistent with the relevant agencies and the CZMA. This includes compatibility with local land use plans, state agency policies (e.g. fish passage, mitigation policies), comprehensive plans, and statewide planning goals.

Goal 16 addresses estuarine resources, and requires individual estuary plans to designate appropriate uses for different areas within each estuary, and to provide for review of proposed estuarine alterations to assure that they are consistent with overall management objectives and that adverse impacts are minimized. Goal 17 is related to coastal shorelands, such as marshes, and emphasizes the management of shoreland areas and resources in a manner that is compatible with the characteristics of the adjacent coastal waters. Goal 18 sets standards for development on beaches and dunes (e.g., dune grading, shoreline armoring), which helps to minimize impacts to Species of Greatest Conservation Need, such as **Western Snowy Plover**, and **Coastal Dunes**, a Key Habitat. Goal 19 is specific to open ocean resources and includes state agency interests, such as implementation of the **Territorial Sea Plan**. For more information on the governance of Oregon's nearshore marine environment see **Appendix** - **Nearshore Management Framework**.

The program's goals also include working lands, which represent a significant portion of Oregon's land and income base. Oregon's planning program protects **working lands** through Goals 3 and 4, which include zoning protections for agricultural and forestlands. **Statewide Planning Goal 3** is for the preservation and maintenance of agricultural lands for farm use. **Statewide Planning Goal 4** protects working forest land around the state, preserving it for commercial forestry while specifically recognizing its value for fish and wildlife habitat, recreation, and protection of air and water quality. These goals protect working landscapes, and by doing so, create benefits to fish and wildlife habitat, recreational opportunities, and protection of scenic landscapes. The Oregon Department of Forestry also tracks land use change on working forestlands in their **Forests, Farms and People Report**, which acknowledges the benefits of protecting working lands through the land use program. **DLCD's 2022-2023 Oregon Farm and Forest Land Use Report** specifically highlighted the co-benefits of protecting working lands for conservation of wildlife habitat using Priority Wildlife Connectivity Areas. This report also acknowledged that changes to the Goal 3 and 4 programs over the past 50 years, such as adding new uses or allowing substandard partitions for certain uses, have not necessarily considered erosion of the co-benefits the programs have for the conservation of Goal 5 habitat values. The 2023-2031 **DLCD Strategic Plan** includes a focus on conserving Oregon's natural and working lands, with an objective to improve natural resource protection and **climate resiliency**.

Smart and sustainable planning is necessary to maintain a healthy environment, maintain habitat connectivity, adapt to climate change, and provide livable communities. A **2019 Oregon Values and Beliefs** survey found that Oregonians value nature and the outdoors, with an emphasis of the importance of accessing nature. Protection of resources that provide the livability and quality of life that Oregonians rate highly can be balanced with efficient urban and rural development through land use planning.

ANTHROPOGENIC LAND USE

People's presence on the land alters the shape, appearance, and function of terrestrial and aquatic ecosystems, influencing fish and wildlife populations. According to the Portland State Population Research Center, an estimated 4.2 million people lived in Oregon in 2024, and the population will continue to grow. As demand increases for housing, energy, infrastructure, and recreation, both urban and rural landscapes face mounting pressure. These land use changes result in significant and often permanent impacts to fish and wildlife habitat. This includes both direct and indirect anthropogenic impacts, at an individual or cumulative scale, which can significantly impact movements, habitat use patterns, and ultimately survival with reproduction and overall population performance declines. Examples anthropogenic impacts include:

Direct Habitat Loss and Fragmentation:

- *Permanent Habitat Loss*: Land use conversion of Key Habitats often results in complete and irreversible loss of habitat function and value. Mitigation may be recommended to offset or replace those losses. Restoration to a natural state is rarely feasible once areas are urbanized. Species may lose access to habitats necessary for critical life-history needs, such as breeding, migration, or overwintering.
- *Habitat Fragmentation*: Development disrupts habitat connectivity, impacting **wildlife movement, migration routes**, and access to seasonal ranges, which threatens long-term species viability. Infrastructure like roads and fences can act

as barriers to terrestrial species, while culverts and dams can restrict aquatic species from reaching essential spawning habitats. Roads and railroads introduce mortality risks through vehicle collisions and can further isolate populations.

Indirect Habitat Impacts:

- *Disturbance from Human Activity*: Noise, artificial light and human presence can disrupt wildlife behaviors, such as breeding, foraging and migration, especially for amphibians, birds, and bats.
- *Reduced Fitness and Displacement*: Fish and wildlife may be displaced from high-quality habitats into areas with inadequate forage or cover or increased threats, which may lower survival and reproductive rates.

Water Quality and Aquatic Habitat Degradation:

- *Stream, Wetland, Floodplain and Riparian Habitat Alteration*: Development along streams can degrade or remove riparian buffers important for fish and wildlife, increase **water temperature**, and reduce off-channel habitat. Reduced water quality can lead to algal blooms and reduced oxygen levels, which are lethal for many aquatic species.
- *Impervious Surfaces*: Conversion of habitat to urban and rural uses can increase the extent of impervious surfaces, such as paved streets and parking lots, which alter hydrology, degrade water quality through runoff, reduce vegetation cover and diversity, and spread **invasive specie**s.

Disruption of Natural Disturbance Regimes:

- *Natural Fire and Hydrological Regimes*: Land use changes interfere with **natural fire regimes and hydrological flows**, affecting ecosystem function and resiliency. Many ecosystems depend on these natural regimes, and without them, habitat quality may decline, and invasive species may dominate.

Private Lands

Private and public lands play a critical role in providing **Key Habitat** for **Species of Greatest Conservation Need**. While 50% of the land in Oregon is in public ownership, many of the most critical fish and wildlife habitats are found on private lands. Even small development actions can result in cumulative landscape level impacts leading to significant population level effects for some species. Therefore, partnerships with private landowners, state and federal land management agencies, and tribal partners are critical to collaborate on measures to protect and manage sensitive life-history needs. These activities include habitat protection, managing recreational opportunities and other public land management, and the challenges that arise from increased development pressures.

Outdoor Recreation

With the growing human population in Oregon comes additional pressure on land managers to increase access to outdoor recreation opportunities such as hiking, mountain biking, and operating off-highway vehicles (OHV). Direct impacts from recreation on animals include fleeing from humans entering an area, altered feeding behaviors, or even changes in reproductive behavior. Disturbance can reduce overall fitness of individuals and increase risk of mortality. Impacts of recreational activities to SGCN and Key Habitat function needs to be considered in future planning processes. There is an opportunity for land managers and decision-makers to not just slow the loss of habitat but to actively contribute to maintaining and restoring wildlife habitat function while managing community values and priorities. Protection of fish and wildlife habitat and maintaining opportunities for residents and visitors contributes to the economic and nonmarket benefits.

Urbanization And Infrastructure

Goal 9 requires that all local governments have enough land available to realize economic growth and development opportunities, which includes commercial and industrial development-ready lands. **Goal 14** establishes urban growth boundaries (UGBs) around each city or metropolitan area to separate urban land uses from farm and forest working lands. By concentrating urban development and associated impacts, the land use program has been reasonably successful in containing sprawl. In 2023, the Oregon legislature passed House Bill 2001, which directs the LCDC to adopt and amend rules related to housing and urbanization, related to Statewide Planning **Goals 10** and 14. It requires Oregon's cities with a population over 10,000 to plan for and encourage housing production, affordability, and choice through a Housing Capacity Analysis and a Housing Production Strategy. In 2023, Governor Tina Kotek also established a Housing Production Advisory Council (HPAC) through **Executive Order 23-04,** which established an annual housing production goal of 36,000 additional housing units at all levels of affordability across the state to address Oregon's current housing shortage and keep pace with projected population growth. That's about an 80 percent increase over current construction trends – and will set Oregon on a path to build 360,000 additional homes over the next decade.

Meeting these housing needs will require cities to implement strategies that consider how development projects may be affected by risk of natural hazards (e.g., floods, landslides, wildfires), and how to successfully facilitate housing production while minimizing impacts on water supplies. The **Integrated Water Resources Strategy** includes recommendations for improving the integration of **water quality and quantity** information into land use planning and encouragement of low impact development practices and green infrastructure to minimize impacts. This includes the protection of groundwater aquifers and wetlands, which support fish and wildlife habitat, as well as recommendations to update land use protections for riparian areas and wetlands through Statewide Planning Goal 5.

Most housing development takes place within **urban growth boundaries** and **natural resources within urban areas** provide essential functions and values to local communities and contribute to watershed health for fish and wildlife species. **Wetlands** and **riparian habitat** within urban areas provide essential corridors for animal movement, many that are identified as **Priority Wildlife Connectivity Areas** (**PWCA**) or **Conservation Opportunity Areas**. **The Oregon Department of State Lands** works with local governments on integrating these aquatic resources into land use planning efforts, as well as with development projects to avoid, minimize and mitigate aquatic impacts through implementation of the **Oregon Removal-Fill Law.** For example, DSL may incorporate best management practices for native turtles, such as the Northwestern Pond Turtle, in wetland development projects, the **ODFW Residential Dock Guidelines** and **the Oregon Guidelines for Timing of In-Water Work to Protect Fish and Wildlife** for overwater structures.

Protection of fish and wildlife habitat, such as maintaining tree canopies within urban areas, also helps to buffer impacts from climate change. As cities replace natural land cover with pavement, buildings and other surfaces that absorb and retain heat, urban heat islands can occur. Due to **climate change**, extreme weather events, such as extreme heat, can increase in frequency and severity. Increasing tree canopy cover in an urban area not only reduces carbon dioxide but also helps address the urban heat island effect and improve air and water quality.

Rural Land Conversion

With increasing population and economic development, rural landscapes are changing, leading to conflicting uses within and adjacent to fish and wildlife habitat. For example, rural residential development for single-family homes, destination resort siting, and other large-scale developments such as mining operations and renewable energy can result in direct habitat loss or cause species to change their distribution and habitat use patterns in response to disturbance. Impacts of development can go beyond the actual footprint of structures or roads. For example, increased water use or groundwater pumping within a development can reduce surface water quantity, impairing wildlife access to free water sources, which may lead to reduced ground water and soil moisture affecting vegetation growth patterns. Many local comprehensive plans acknowledge conflicting uses from rural developments and include habitat protections, such as housing density standards, siting standards (e.g., requiring wildlife friendly fencing), and clustering techniques to minimize habitat fragmentation.

Natural Resource Extraction

Natural resource extraction, such as mining for aggregate and critical minerals, also has direct and indirect impacts to fish and wildlife habitat. **The Oregon Department of Geology and Mineral Industries** is the state agency responsible for working with permittees to coordinate mine permitting through all the required agencies to minimize impacts of natural resource extraction. Impacts to fish and wildlife habitats may include habitat conversion, habitat fragmentation from roads, direct habitat loss as a result of the mine development and extraction processes, and indirect impacts such as noise, disturbance and runoff as a result of the mining operations. Aggregate mining in the floodplain may remove riparian vegetation, alter stream channels and entrap fish in the mining pits. Sagebrush habitat in southeastern Oregon has been targeted for mining exploration for **critical minerals**, such as lithium, and proposed mining for gold. Mining in **Sagebrush** habitat may affect **Greater Sage-Grouse**, Burrowing Owls, pygmy rabbits, and other SGCN, which depend on intact habitats to persist. Early coordination regarding the impacts to Key Habitats and SGCN during the exploration phase and throughout the project development process is important to ensure that potential impacts are accurately identified, avoided, and minimized to the degree possible through best management practices, and mitigated where impacts remain after avoidance and minimization measures have been implemented.

Renewable Energy

Oregon has set aggressive goals for decarbonizing the state's energy system, with an objective of **100% renewable energy by 2040.** This timeline has created a high interest in the development of new solar and wind energy facilities within the state. As more energy projects are established on Oregon's landscape, there will be cumulative impacts to the availability, quality, and accessibility of viable habitat. In addition, the regional demand for a cleaner energy system and increased power needs for emerging technologies will continue to drive renewable energy development. The primary renewable energy developments are photovoltaic solar and wind energy. Each of these development types can have differing direct and indirect impacts on the landscape. Direct impacts include habitat loss from the development footprint or exclusion by project fencing. Indirect impacts include increased disturbance during construction and maintenance activities within facilities, habitat fragmentation from roads and fences associated with project development, and wildlife avoidance of project areas. Wind development projects generally have lower amounts of total disturbed habitat than solar facilities, but the footprint is distributed over a greater number of acres. Potential impacts from wind facilities are assessed using the **US Fish and Wildlife Service Wind Energy Guidelines**, providing a consistent approach nationwide to assessing direct mortalities and displacement generally associated with wind development.

The **Columbia Plateau** ecoregion has seen considerable wind and solar energy development over the past two decades, given its resource potential and proximity to transmission. Other portions of eastern Oregon have seen solar development proposals, with the highest solar irradiance in the state found in the **East Cascades**, south of Bend, and the **Northern Basin and Range**. Other potential energy generation technologies being explored in Oregon include geothermal, offshore wind, and wave energy. The existing electric transmission system will also need to be upgraded to maintain reliable service, meet new demand, and connect renewable energy development to electric loads. Additional infrastructure associated with energy, including access roads and pipelines, can also impact the landscape.

DLCD has developed administrative rules for **wind and solar energy siting** on agricultural land based on input from energy providers and conservation groups. DLCD rules provide guidance and direction regarding local land use decisions for solar and wind facilities, and policies for siting ocean energy facilities. However, the **Oregon Energy Facility Siting Council** or the **Federal Energy Regulatory Commission** makes the siting decisions for large energy facilities and transmission infrastructure. Regardless of the regulatory pathway, engagement by state, federal, tribal, and conservation partners is key to balancing energy development with impacts to fish and wildlife and their habitats.

In 2019, the Oregon Department of Energy (ODOE) partnered with DLCD and the Oregon Institute for Natural Resources (INR) on a grant application to the U.S. Department of Defense for the study and assessment of renewable energy and transmission development in Oregon. The **Oregon Renewable Energy Siting Assessment (ORESA)** is an online mapping and data portal that includes consideration of important fish and wildlife habitat for proactive energy siting.

The effects of **climate change** on Oregon's habitats and species are becoming more evident, and state policies are becoming more ambitious in identifying potential pathways to reduce or slow the rate of change realized. Current state goals for removing carbon from Oregon's energy portfolio are diverse but will all require siting for new renewable energy projects in the state. Energy projects offer environmental benefits but also have impacts on fish, wildlife, and habitats. So far, energy policy has focused on the broad need to reduce emissions (e.g., **Northwest Power Planning Council**), but typically does not address local or site-level impacts. At the same time, site evaluations for specific projects typically focus on the immediate and local effects of a project, without consideration of its broader benefits. Climate change and the increasing call for clean energy challenge agencies and partners to work together in seeking creative ways to bridge the gap. Future policies to guide new clean energy development should outline a collaborative vision for energy siting practices, and, while recognizing the immediate but dispersed value of clean energy across Northwest landscapes, should incorporate fish, wildlife, and habitat values.

LAND USE PLANNING: GOALS AND ACTIONS

Goal 1: Manage land use changes to protect and conserve farm, forest, and range lands, open spaces, natural or scenic recreation areas, and fish and wildlife habitats.

Action 1.1. Encourage the updates of local land use plans and ordinances that protect Key Habitats to support fish and wildlife.

Many important decisions about land use occur at the local level through comprehensive land use plans. These plans consider local values, priorities, and needs. Agencies will need to work with local community leaders and other stakeholder groups to find opportunities to incorporate SGCN, Key Habitats, Conservation Opportunity Areas, Priority Wildlife Connectivity Areas, and other priorities into local plans that conserve farmlands, forestlands, open space, and natural areas. This should include working with DLCD and local governments to adopt land use ordinances that incorporate measures into land use reviews and decisions that avoid, minimize or mitigate conflicting uses to fish and wildlife habitat. Promote ordinances that minimize habitat fragmentation, establish riparian buffers to protect water quality and temperature, require wildlife friendly fencing, include timing and seasonal restrictions to minimize disturbance during sensitive life history stages and mitigation for unavoidable impacts. The opportunity to re-establish periodic reviews for fish and wildlife data to ensure incorporation of newly acquired information needed to inform land use management decisions should also be explored. The **Integrated Water Resources Strategy** also includes recommendations for water planning, which includes integrating water data and information in land use planning that can support habitat functions for fish and wildlife.

Technical assistance, such as outreach and education, will be necessary to support local governments and stakeholders to integrate current data. Support and partnerships are necessary, which may involve the creation of toolkits, guidance and training for integrating habitat conservation into development planning and permitting. For example, Oregon would benefit from development of a **Green Growth Toolki**t to assist communities in implementing conservation actions and proactively planning for growth as development pressures increase. It is important to acknowledge the challenges that arise when trying to balance resource protection, economic development, and social considerations in development projects. However, it is possible to plan for contained, well-designed growth which can avoid and minimize impacts to surrounding landscapes and help conserve fish, wildlife, and habitat, as well as working lands.

Action 1.2. Encourage land use planning efforts to integrate opportunities for addressing climate change, such as climate-smart practices and nature-based solutions in development actions.

The **Oregon Climate Adaptation Framework** identifies the need to “Leverage the statewide land use planning program and develop land use planning guidance based on Oregon’s Statewide Land Use Planning Goals to help cities and counties mainstream climate science and engagement of diverse communities into their planning, permitting, and operations” as an adaptation strategy. It also acknowledges the need to review the Planning Goals as challenges related to **climate change** were not anticipated when the foundational program was established. This provides an opportunity to acknowledge and integrate the co-benefits of protecting and restoring riparian, floodplain, and wetland habitats as a climate adaptation strategy. Most comprehensive plans have identified natural resources through Statewide Planning Goal 5, as well as through Goal 16 for estuarine resources, but most do not adequately consider habitat functions or values, especially to address new environmental, social, and economic challenges of climate change. Habitat protection and restoration as a climate adaptation strategy may also be achieved through **natural hazard planning**. Integrating nature-based solutions through planning (e.g., incentives, ordinances), design, and engineering practices can address natural hazards (e.g., erosion, landslide risk, wildfire risk, flood storage, water quality), protect and enhance fish and wildlife habitat, and enhance community resilience. The Integrated Water Resources Strategy also acknowledges the challenges from land use and climate change and recommends actions to protect and restore green infrastructure. This includes protection of wetlands, floodplains, and forests, which can help to address climate mitigation and adaptation. DLCD is also addressing mitigation and adaptation of climate change **related to land use** and transportation, natural hazard planning and coastal management. ODFW also adopted a Climate and Ocean Change Policy in 2020 that directs ODFW to prepare for and respond to the impacts of climate and ocean change on fish, wildlife and their habitats.

Many local governments in Oregon have already or are in the process of developing climate action plans for their communities, as well as some local governments considering updates to their estuary management plans. These community-driven efforts usually include scenario planning and conducting a vulnerability analysis for the environmental, economic, and societal impacts from climate change. Opportunities to incorporate tools, such as Conservation Opportunity Areas and Priority Wildlife Connectivity Areas, may be useful in identifying climate focal areas to protect and restore floodplain and riparian habitat, as a strategy to comply with the floodplain requirements and meet greenhouse gas metrics through carbon storage (e.g., blue carbon) and carbon sequestration. Prioritizing habitat through actions such as nature-based solutions can optimize societal and ecological benefits by reducing exposure to climate hazards, reducing sensitivity to adverse effects, and building adaptive capacity of local communities. There are also opportunities to integrate low impact development and green infrastructure to increase climate resiliency as Oregon experiences increased temperatures, drought, and flooding.

Action 1.3. Encourage strategic land conservation and restoration to protect Key Habitats using a suite of tools, such as financial incentives, conservation easements, landowner agreements, mitigation, and targeted acquisitions.

A range of incentives and conservation tools will complement landowner's unique circumstances and priorities. Outreach to partners, including land managers and local governments, can provide information about incentives to conserve **SGCN, Key Habitats**, **PWCAs**, and **Conservation Opportunity Areas**. The State Wildlife Action Plan Conservation Toolbox provides a summary of **voluntary, non-regulatory approaches** to conserving fish and wildlife and recommendations to further assist willing landowners to protect and restore Key Habitats.

It is also important to promote partnership opportunities for protection of natural and working lands. This may include opportunities for working lands conservation easements, such as through the Natural Resource Conservation Service **Agricultural Conservation Easement Program through Agricultural Land Easements** or local land trusts. There are also many existing incentive programs to conserve natural and working lands, such as **ODFW's Wildlife Habitat Conservation and Management Program**. The **Oregon Wetland Program Plan** includes a Core Element of "voluntary wetland restoration and protection", with a focus on restoration and protection, including actions for continuing stream and wetland restoration, and working with counties to enroll properties in the ODFW tax incentive programs. Other programs through the Oregon Watershed Enhancement Board, such as the **Oregon Agricultural Heritage Program** funds voluntary incentives to support practices that maintain or enhance both agriculture and natural resources such as fish and wildlife habitat on agricultural lands.

In many land use permitting processes, ODFW may recommend mitigation to offset unavoidable impacts to fish and wildlife habitat. Identification of places with broad conservation opportunities can direct potential mitigation projects to areas with the highest ecological value.

Goal 2: Work proactively and collaboratively to encourage land development actions that are well-sited, adequately mitigated, and responsibly operated to conserve Species of Greatest Conservation Need and Key Habitats.

Action 2.1. Increase access to and use of the best available data and maps to plan for and site land development that avoid or minimize impacts on fish, wildlife and their habitats.

As Oregon continues to plan for future growth, the Statewide Land Use Planning Program and Planning Goals should still be the foundation. Local governments, state agencies, conservation organizations, private industry, tribes, and the general public need access to the best available data for land use decisions to avoid and minimize impacts. Spatial information on Species of Greatest Conservation Need, Key Habitats, Conservation Opportunity Areas, **Oregon Fish Habitat Distribution and Barriers Data**, **PWCA** and other mapped information for Oregon is available using the **ODFW Compass** mapping application. Agencies and organizations are encouraged to continue to share information, data, and analyses on fish and wildlife habitat function for integrating into development planning and projects. This may include emphasizing a priority on previously disturbed sites, or in areas which avoid Key Habitats and wildlife movement corridors. Agencies, such as DEQ and DSL also have designations for protecting Key Habitats. For example, DEQ designates cold water habitat, and DSL designates and protects Aquatic Resources of Special Concern, which include many Key Habitats (e.g., wet prairie, vernal pools, interdunal wetlands) that are either naturally rare or have been disproportionately lost due to prior impacts.

For renewable energy projects, this means working with utilities and planners to co-locate transmission within existing infrastructure to help offset potential impacts from development. For management of recreational uses, this may include co-locating any new trail, road or other needed amenities in areas that are already disturbed and experienced a high level of impact.

Reducing emissions is an important step towards slowing down the impacts of climate change in the Pacific Northwest. Accomplishing these broad goals can be achieved by using the best available information, with additional technical assistance and local data from Oregon's natural resource agencies. Agencies and partners can work to provide the tools, scientific knowledge, and assistance needed to support consistent, defensible, and predictable siting decisions and operational requirements. The Oregon Department of Energy hosts the Oregon Renewable Energy Siting Assessment tool (**ORESA**) that was developed specifically to serve as a central clearinghouse for data from multiple organizations, and serves as a decision support tool for all entities engaged in energy siting. Available guidance documents include the **ODFW Solar Siting Guidance (2024)**, **Oregon Columbia Plateau Ecoregion Wind Energy Siting and Permitting Guidelines (2008)** and the **USFWS Land-Based Wind Energy Development Guidelines (2012)**. In addition, the **Association of Fish and Wildlife Agencies** hosts resources from across the nation, many of which can inform issues that may be new to Oregon. However, these guidance documents are just a beginning. Further actions to enhance the availability and use of the best available science should engage natural resource agencies to develop clear and comprehensive mitigation strategies and siting guidance for all types of energy development.

Action 2.2. Encourage engagement in regional, statewide and federal planning priorities, such as those related to energy and housing, to promote collaborative solutions and strategies that incorporate consideration of Key Habitats and Species of Greatest Conservation Need, including the consideration of cumulative impacts.

Proactive engagement with land use managers and planners, agencies and project developers as Oregon continues to experience land use pressures is essential to ensure that the best available data for fish and wildlife is being considered. This includes seeking collaborative solutions and the development of shared goals, priorities and strategies. There are multiple statewide plans that prioritize goals for Oregon that reference the land use planning program but it's important to better align the shared interagency priorities. This could include strategic mapping efforts, such as the prioritization of protection of natural and working lands, that provide co-benefits to fish and wildlife habitat. Opportunities for providing technical assistance and outreach to stakeholders is also critical for collaboration and engagement.

Additional coordination across stakeholders is also needed to evaluate and monitor the impacts to species and habitats of large-scale development projects. This includes a better understanding on how large-scale developments affect wildlife habitat use and movement, population level impacts, and cumulative habitat loss. Partnerships will be critical to implement this need.

ADDITIONAL RESOURCES

Oregon Land Use Planning Online Training

Oregon Integrated Water Resources Strategy (2025)

Climate Adaptation Framework

ODFW Climate and Ocean Change Policy

Oregon Explorer

Oregon Guidelines for Timing of In-Water Work to Protect Fish and Wildlife Resources (2024)

ODFW Residential Dock Guidelines (2016)

Oregon Climate Action Commission and Natural and Working Lands Report

1000 Friends of Oregon: Death by 1000 Cuts (2020)

Defenders of Wildlife: No Place for Nature (2001)

Lincoln Institute of Policy and Planning: Integrating Land Use and Water Management

The Big Look (2009): The Oregon Task Force on Land Use Planning Final Report

The Oregon land use system: an assessment of selected goals INR Report (2008)

ODFW Solar Siting Guidance

Energy Facility Siting Standards

Renewable Portfolio Standard

Association of Fish and Wildlife Agencies Energy and Wildlife Program

American Wind Wildlife Institute

Defenders of Wildlife Renewable Energy Program

National Energy Technology Laboratory Research

American Clean Power Association Resources

Columbia Plateau Wind Energy Siting Guidelines

Renewable Northwest

USFWS Eagles in the Pacific Northwest: Energy, Utilities, & Guidance

POLLUTION

BACKGROUND

Pollution comes in many forms, threatening fish, wildlife, habitats, and human health. Pollutants can impact soil and water quality, degrade habitat, cause physiological and behavioral impacts to fish and wildlife, increase susceptibility to disease, cause injury or mortality, and in severe cases can make habitat unsuitable for fish and wildlife and unsafe for people.

Pollutants originate from many places— sewage, wastewater and stormwater, industrial products, mining activities, oil spills, some agriculture and forestry activities, garbage and solid waste, emissions from fossil fuel combustion, noise, light, and other human activities. As a result of the diversity of impacts and the often-broad spatial scales at which they occur, pollution directly or indirectly affects nearly all of Oregon's fish and wildlife species. The impacts of some pollutants on fish and wildlife, such as microplastics, nanoplastics, and pharmaceuticals, have not been well-studied. Research is needed to better understand the ways they interact with natural systems.

While improvement to wastewater treatment facilities, reduction in the use of broad-spectrum pesticides, and other environmental regulations have reduced certain contaminants, pollutant sources and quantities will likely increase as Oregon's human population continues to grow and industries expand. Due to the widespread impacts on fish, wildlife, and their habitats, managing pollution is necessary to sustain healthy and productive ecosystems.

TYPES OF POLLUTION

Water-borne Sewage and Urban Wastewater

CMP Direct Threats 9.1

Wastewater

If not properly managed, wastewater discharge can introduce a wide variety of pollutants into aquatic systems. Discharge from septic systems, industry, and wastewater treatment facilities can carry toxic chemicals, heavy metals, sediments, pharmaceuticals, nutrients, bacteria, petroleum products, and sewage overflow into wetlands, lakes, rivers, estuaries, and nearshore environments. Contaminants present in water can impair development, fertility, and reproductive function in aquatic and terrestrial species, including humans. Contamination from wastewater has also been linked to declines in aquatic species diversity, richness and abundance, and survival. Additionally, nutrient pollution from municipal wastewater is one of the primary drivers of harmful algal blooms.

Stormwater

Stormwater runoff from impervious surfaces, such as roads and parking lots, accumulates petroleum products, metals, microplastics and nanoplastics, road salt and deicing chemicals, tire-associated compounds, and other contaminants. Introduction of these pollutants into natural systems can have a variety of negative impacts. Heavy metals introduced to natural waters display high toxicity and accumulate in food webs, leading to direct and indirect mortality of fish and wildlife. Certain compounds used to make tires more durable are acutely toxic to some fish species and stormwater runoff containing tire particles can expose fish to 6PPD-quinone, which is lethal for coho salmon and steelhead. 6PPD-q may also have negative impacts on other aquatic species including amphibians, turtles, and aquatic invertebrates, but existing research is limited, and additional study is needed to evaluate potential toxicity for these taxa. Excessive nutrient loads from introduction of nitrogen and phosphorus in runoff can change plant composition in wetland communities and increase the prevalence of algal blooms, which can kill or displace fish and invertebrates.

Industrial Pollution

CMP Direct Threats 9.2

Industrial activities can introduce pollutants into the atmosphere and aquatic systems as byproducts of production processes, fossil fuel combustion, or waste management practices.

Persistent Organic Pollutants

Industrial pollutants can include persistent organic contaminants, such as dioxins, polychlorinated biphenyls (PCBs), hexachlorobenzene (HCB), polycyclic aromatic hydrocarbons (PAHs), plastics, per-and polyfluoroalkyl substances (PFAS), and flame retardants and firefighting water additives, among others. Organic compounds may be transported widely by atmospheric and ocean currents, and deposits can accumulate and persist in sediments, causing far-reaching impacts. Many of these substances are toxic and accumulate in human and animal tissues. Bioaccumulation of pollutants, wherein substances build up in an organism’s tissues over time, can pose risks to species, including humans, that consume polluted substances. These effects are frequently amplified across food webs, and over time, high levels of accumulated pollutants may result in severe toxicity and death.

Even at low levels, persistent organic pollutants stored in fat tissue may be released during periods when wildlife rely on fat stores, such as during migration, egg laying, or lactation, increasing risk of mortality during these sensitive times of the year. Persistent organic pollutants may also be transferred from mother to offspring in-utero. Fish consumption advisories for pollutants such as PCBs, dioxins and other pesticides have been issued for many waterbodies across Oregon. In some cases, state health officials have recommended limiting the consumption of resident fish species due to elevated levels of these contaminants.

Impacts from Mining Activities

In addition to persistent organic contaminants, industrial activities can introduce toxic heavy metals into natural systems. Mineral extraction or processing can have long-term negative effects on mine lands and surrounding ecosystems, including bioaccumulation of heavy metals, increases in species’ susceptibility to disease, reductions in population sizes, reproductive impacts, and can even result in mass mortality for aquatic species along entire stream reaches.

There are four main types of water quality impacts from mining activities: acid mine drainage, heavy metal contamination and leaching, chemical pollution from metal processing, and erosion and sedimentation. Acid mine drainage occurs when sulfide minerals are excavated, and the large quantities of exposed rock react with water and oxygen to form sulfuric acid. The acid is deposited into nearby waterbodies through stormwater runoff and may cause degradation of water quality and impacts to aquatic life. Water contaminated by acid mine drainage may be toxic to aquatic organisms including fish, such as chinook and chum salmon, aquatic wildlife, and invertebrates. Other impacts include heavy metal pollution, caused when metals in excavated rock are exposed to water and are leached out into downstream systems, and chemical processing pollution, when chemicals such as cyanide and sulfuric acid that are used to process mined metals spill or leach into nearby waterbodies and groundwater. Since mining activities disturb large amounts of rock and soil, substantial amounts of sediment can be carried into freshwater systems and may bury spawning gravels, disturb or destroy eggs, and smother aquatic organisms and vegetation. Pollutants from mining activities can have substantial negative impacts on aquatic wildlife, including reduced growth rates, hatching failures of fish and amphibian eggs, impacts to breathing, behavior, and reproduction, and increased rates of mortality.

Oil Spills

Sources of oil spills may include pipeline, rail, truck, or ship accidents, unintended spillage from the cleaning of oil tanks, and runoff from urban areas and roadways. The effects of oil spills may be localized or extensive, depending on the source of contamination. Wildlife can be directly poisoned if oil is ingested, or animals may be inhibited by oil coating fur or feathers. Oil can cause significant mortality to fish and aquatic invertebrates, especially to the eggs and larvae of many species and to organisms that are fixed in one location, such as oysters and other shellfish. Habitats may remain impaired long after an initial oil spill response because oil can persist for long periods of time in the environment.

The water-soluble components of various types of crude oils and refined petroleum products contain compounds that are toxic to many types of plants and animals. Animals can suffer from skin irritation and chemical burns, respiratory issues, and neurological problems due to oil spills. Feathers of birds exposed to oil lose their ability to insulate, repel water, and aid in buoyancy, which can lead to death. Marine birds that feed intertidally in sandy beach habitat or in the surf-zone are especially vulnerable to oiling. Bird species may also ingest oil, either directly or by consuming oiled prey, which may lead to poisoning or death. In addition, large amounts of stranded oil may smother and kill fish, wildlife, and invertebrates.

While many of Oregon’s habitats may be impacted by oil spills, aquatic habitats are particularly vulnerable. In marine systems, offshore, water-soluble fractions of crude oil and refined petroleum products can cause immediate toxic effects on all life stages of marine organisms. Floating oil is more likely to impact plants and animals on the water’s surface than those residing deeper in the water column. Plankton occurring in the top layers of the water column are exposed to the highest concentrations of these compounds, which can result in direct and indirect effects to plankton and the host of species that are dependent on the quantity and quality of phytoplankton primary productivity. Alterations to phytoplankton productivity appear to only last for short periods of time but can have significant effects on oceanic species. Kelp beds are similarly vulnerable to exposure to crude oil and refined petroleum products.

In inland systems, lakes, rivers, and wetlands may also be impacted by oil spills. Freshwater oil spills are more frequent, particularly in or adjacent to urban areas, and are often more destructive to local environments than marine spills. Habitats with standing water, such as wetlands, are likely to experience more severe impacts from oil spills as oil pools in the water and can persist for long periods of time. Spilled oil is toxic to freshwater organisms, including mammals, amphibians, reptiles, birds, fish, insects, microorganisms, and vegetation. Oil may coat vegetation in wetlands or cling to bankside vegetation along lakes and rivers. Oil can also accumulate in sediments, with significant negative impacts to many worms, insects, and shellfish, as well as species that live in or feed off the sediments.

Agricultural and Forestry Pollution

CMP Direct Threats 9.3

Agricultural and forestry activities are critical for food and materials production, but certain agricultural and forestry practices can have detrimental effects on natural systems, including application of fertilizers and pesticides and poor sediment management. Forestry related stream sediment input is highly regulated in Oregon, and practices that prevent chronic sediment delivery and avoid direct stream channel disturbance are recommended.

Agricultural runoff is the leading cause of water quality impacts to rivers and streams, the second largest source of impacts to wetlands, the third leading source for lakes. Fertilizers applied to farmlands that are not taken up by crops ultimately wash into water bodies or wetlands. Fertilizers entering aquatic systems contribute surplus nutrients, particularly nitrogen and phosphorus, that can change plant composition in wetland communities and can cause harmful algal blooms, reducing dissolved oxygen concentrations enough to kill or displace fish and invertebrates. Nutrients and bacteria in livestock manure have similar effects.

Pesticides applied during agricultural production, in the form of insecticides, herbicides, and rodenticides, have also been found to have significant negative effects. Broad-spectrum chemical herbicides applied to forests to control vegetation regeneration following timber harvest or applied to agricultural lands to control outbreaks of unwanted plant species can impact wildlife habitat and forage availability and can significantly reduce populations of arthropods that serve as prey for a diversity of birds, small mammals, reptiles, and amphibians.

While many of the more dangerous broad-spectrum insecticides are no longer in widespread use, new classes of insecticides have been documented to have significant direct and indirect impacts to non-target species. Neonicotinoids are a newer class of synthetic broad-spectrum insecticide, typically applied to seeds before planting or directly to the soil to prevent insect damage to growing plants. Neonicotinoids are now the most widely used class of insecticide in the United States.

It is difficult, however, to limit the impacts of these insecticides to just target species. Neonicotinoids have been implicated in declines in numerous pollinator species, including native bees and butterflies. Their widespread use and environmental persistence have led to contamination of aquatic systems, including wetlands, streams, and rivers. Use of neonicotinoids has also been correlated with impacts to vertebrate populations, with links to several widespread population declines in bird species.

In addition to insecticides, many agricultural operations rely on application of rodenticides to limit foraging activities of rodents on growing plants or on grain stores. In particular, anticoagulant rodenticides have been found to have widespread deleterious effects on both target and non-target species. These rodenticides are used to kill mice, rats, and other rodents by preventing blood clotting. However, the mechanism of action for these rodenticides is not immediate, meaning that rodents may be preyed upon by other species prior to succumbing to the effects of the poison, or scavenged after a lethal dose has taken effect. As a result, these compounds have been implicated in the deaths of raptors, fisher, bobcats, foxes, coyotes, and a variety of other non-target species through secondary exposure after ingesting poisoned rodents.

Agricultural activities that disturb soils, such as tillage, alongside certain timber harvesting activities, contribute to soil erosion and runoff of sediments into aquatic systems. Excess sediment can impact water quality, alter hydrology, increase turbidity of waters, bury cobble and gravel substrates critical to fish spawning and populations of in-stream insects, reduce hatching success of aquatic eggs, and limit plant growth, significantly altering community composition. Most detrimental effects of timber harvest on soils are related to the development and use of roads and the movement of vehicles and machinery, which can disturb the soil surface.

[Spotlight] The Private Forest Accord

The Private Forest Accord (PFA) was a landmark agreement made between representatives from Oregon’s timber industry, the Oregon Small Woodlands Association, and prominent conservation and fishing organizations in 2022, to modify portions of Oregon’s forest practice laws and regulations in a way that expands protections for fish and amphibians while providing long term regulatory assurances. The changes to the Oregon Forest Practices Act are aimed to avoid and minimize the effects timber harvests and other forest management activities on private forestlands have on these species and the aquatic habitats they depend on. The PFA improves the protections of the stream network by relying on rigorous and modern scientific approaches to delineating the fish bearing and perennial stream networks to assure that streams are fully protected under the correct management system for the type of the stream and increased coordination with the Oregon Department of Fish and Wildlife (ODFW). It called for expanded no-cut buffers along streams, which are areas where trees must be left unharvested and new standards for forest roads and culverts to remove barriers to fish passage and limit sediment runoff. A key part of the PFA involves the Oregon Department of Forestry (ODF) developing a federally approved Habitat Conservation Plan (HCP) for private forestlands, which is a planning document designed to accommodate economic development while protecting threatened or endangered species. The PFA also established the ODFW mitigation fund and grant program to support projects that benefit fish and aquatic species, as well as to address the impact of timber harvest and forest practices. Watershed-scale investments in projects like stream habitat restoration, removal of barriers to fish passage, cold water and flow protection, beaver-modified habitat creation, and more will create statewide benefits for the species covered by the Private Forests HCP. These voluntary updates will limit adverse effects of sedimentation and turbidity to surface waters, and represent a success story for productive partnership in limiting pollutant impacts to fish, wildlife, and habitats. [LINK to Water Quality KCI].

Garbage and Solid Waste

CMP Direct Threats 9.4

Litter, food waste, discarded or lost hunting and fishing gear, and other solid waste left behind contaminate the natural environment and can directly and indirectly injure or kill wildlife.

Food Waste

Food waste on the landscape can serve as an attractant for animals and can have significant impacts on wildlife behavior and populations. Unsecured food in landfills and waste receptacles, littered food in urban or recreational areas, and pet food left outdoors become an attractive and easy food resource for many species. For some species, such as opportunistic scavengers like corvids and gulls, access to food waste may drastically inflate population sizes. These larger populations may then become pests and threaten other wildlife as they predate on the eggs and young of nesting birds, small mammals, reptiles, and other species. Wildlife that learn to depend on human food waste as a resource may also become habituated, losing their fear of humans and increasing the risk of human-wildlife conflicts. Habituation can also increase the risk of disease transmission due to contact with pets and other wildlife. Encounters with habituated animals may be dangerous and require intervention from wildlife managers or law enforcement. For example, bears habituated to consuming trash from poorly contained waste receptacles, food left outside for pets, or refuse left around campsites may be lethally removed to protect human safety.

Plastics

Plastics, in their various forms, have become ubiquitous, polluting marine, freshwater, and terrestrial systems. Plastic debris can entangle fish and wildlife, causing injury or mortality, and ingested plastics can cause gut obstructions. Plastics also contain organic contaminants, including PCBs, bisphenol A (BPA), and polybrominated diphenyl ethers (PBDEs) that can be harmful when ingested and can leach into groundwater and/or surface waters. Fish and wildlife exposed to these contaminants suffer numerous negative effects, including disrupted immune function, disruption of hormone systems, impacts to reproduction, liver and kidney toxicity, and neurotoxicity. Micro- and nanoplastics, created as plastic litter breaks down over time or shed into the environment from abrasion and wear on products such as synthetic textiles and car tires, have a range of negative impacts on fish and wildlife health. Micro- and nanoplastics are small enough to cause damage to tissues, organs, and even the cells of fish and wildlife, with some studies illustrating stomach lining damage and cell rupture and multiorgan failure due to microplastic ingestion. Ingested micro- and nanoplastics can result in reduced immune system function and reduced fertility across diverse fish and wildlife species. Micro- and nanoplastics can accumulate in tissues over time, with impacts that are magnified at higher trophic levels as predators ingest contaminated prey.

Marine Debris

Marine debris, including derelict fishing gear and plastic, metal, glass, rubber, and other litter, can pose a direct threat to marine life. Lost or abandoned fishing gear, including fishing nets, hooks and lines, crab pots, and other gear, may entangle, capture, and/or kill marine life. This phenomenon is known as “ghost fishing” and not only affects harvested species, but also non-harvested species, which can suffer from entanglement or entrapment, leading to injury or starvation. Ingestion of discarded fishing tackle can also result in severe health consequences for a variety of species. Lost, abandoned, or discarded fishing gear makes up 50-100 percent of plastic debris found in parts of the ocean. Ingestion of plastic litter is a significant issue for many marine species including fish, seabirds, marine mammals, and sea turtles. Cumulatively, the impacts of this debris are significant, causing starvation due to gut obstruction, reduced species fitness, toxicity caused by absorption of toxins from ingested material, and increased mortality.

Lead

Lead continues to be used in both hunting and fishing, including lead ammunition and lead sinkers, and can be inadvertently left behind in the ecosystem. Wildlife can directly consume lead-contaminated material, either through the eating of remains of animals shot with lead ammunition or direct ingestion of shotgun pellets or split shot fishing sinkers as food or grit. Lead poisoning poses a serious threat to wildlife: there is no safe level of lead. When wildlife ingest lead, the lead invades the bloodstream, where it interferes with a variety of physiological processes. Lead accumulates in bone tissue, and acute or chronic exposure can result in lethargy, muscle wasting, organ failure, and ultimately, death.

Illegal Dumping

Illegal dumping, which describes the disposal of materials in locations other than permitted facilities, can pollute local waterways and groundwater, impact human health, and damage fish, wildlife, and marine populations and the environment. Common materials in illegal dumps include used tires, construction debris, old appliances, or other household or commercial wastes. Unlike regulated, permitted facilities, which work to protect the surrounding area from contaminants, illegal dump sites do not have systems in place to manage pollutants.

Air Pollution

CMP Direct Threats 9.5

Wildlife and their habitats are vulnerable to adverse impacts from air-borne pollutants, which can be either natural or anthropogenic in origin, including smoke from forest fires, wind dispersion of pollutants from farm fields and industrial manufacturers, smog from vehicle emissions, and others. Atmospheric pollutants come from both point and nonpoint sources and can impact habitats and ecosystems far from the source of emission. Air pollution can also affect animals differently depending on the way an animal obtains oxygen (through lungs, gills, or diffusion across the skin surface).

Impacts of airborne pollutants to wildlife populations are varied, including disruption of endocrine function, increased vulnerability to stresses and disease, decreased reproduction, or even mortality. Air pollutants can cause significant damage to food webs. Many pollutants are processed and stored in animal tissues and may accumulate over time. Mercury, for example, can become airborne through combustion of fossil fuels, and once methylated is readily taken up by organisms and biomagnified at higher trophic levels. This can cause neurological impairment in wildlife and lead to behavioral, reproductive, or physiological impacts. Air pollutants also have significant impacts on insects, reducing pollinator foraging efficiency, decreasing populations of insects that live within and on the surface of soils, and, in some cases, increasing populations of insects that cause damage to crops, conifers, and other vegetation.

Additionally, air pollutants can enter the water cycle. Acid rain is the direct result of the emission of sulfur dioxide and nitrogen oxides into the air, primarily from the burning of fossil fuels. These chemical compounds can then be transported through wind and air currents, mix with water and other materials in the atmosphere, and fall to the ground as acid rain or in dry deposits. Acid rain can change the chemistry and quality of soils and water. In freshwater and marine systems, this can result in waterbodies that are too acidic for some animals to survive or perform basic functions. The increased acidity may also increase the release of heavy metals from soil into aquatic environments, which may further increase toxicity to aquatic animals.

Noise and Light Pollution

CMP Direct Threats 9.6

Human activity is increasingly responsible for inputs of excess energy into the environment. These inputs can take the form of light and sound, both of which have documented impacts to wildlife and their habitats.

Light Pollution

Light pollution, the brightening of the sky from anthropogenic sources, is the result of unnatural or inappropriate lighting and can dramatically change the nighttime environment. Artificial lighting at night has increased substantially in both urban and rural areas. Outdoor lighting from streetlights, parking lot lighting, vehicle headlights, lights on ships at sea, and lighting associated with housing and buildings has become pervasive. This light pollution has significant, adverse effects on many species, particularly nocturnal invertebrates.

Wildlife depend on the natural cycle of light and dark, and alterations to natural light cycles can disturb flight, impair navigation and vision, disrupt migration, mating, and feeding, and increase susceptibility to predation. Impacts to wildlife are varied: sources of light can both attract and repel organisms, concentrating animals in inappropriate locations or rendering habitat unsuitable for use.

Many species are known to be directly impacted by the presence of artificial lights. Migratory birds often rely on naturally occurring light sources, including the moon and stars, to navigate the night sky. Artificial lights can cause disorientation, attracting birds away from their migratory pathways, leading to excess energy expenditure and, at times, mortality from collisions with illuminated structures such as communication towers and lighthouses. On the coast, light pollution is of particular concern for young seabirds, including petrels and shearwaters, which may be attracted to anthropogenic sources of light on land as they attempt to take their first flights to sea. These species are often incapable of becoming airborne again if they become grounded on land, where they become vulnerable to predation or starvation. Unnatural light sources can also cause diurnal songbirds to vocalize at inappropriate times or change breeding timing. Artificial lights have also been found to alter behavior of amphibian species, including impacts to the calling patterns of frog and toad species. Some frogs are known to gather at lights where entrapped insects provide a concentrated food source, making them more susceptible to predation.

Darkness is a renewable resource, and where feasible, turning off lights and retrofitting existing lights to reduce impacts to wildlife can mitigate harm. Oregon is home to a landscape-level International Dark Sky Sanctuary, the Oregon Outback Dark Sky Sanctuary, which protects over 11.4 million acres of dark skies. Further efforts to limit impacts of light to wildlife can enhance the quality of the nighttime environment for all species.

Noise Pollution

Noise pollution is any unwanted, excessive, or disturbing sound and has wide ranging effects on fish and wildlife populations. Noises generated from industrial activities, resource extraction, transportation, urban areas, and recreation can alter the behavior of terrestrial and aquatic wildlife, particularly animals that communicate with vocalizations, such as birds and whales.

In nearshore and estuarine environments, noise caused by vessel operations, sonar, offshore energy development or production, dredging, construction, and seismic studies may disturb marine mammal and fish populations. Acoustic disturbances may stress, displace, or even damage individuals in the affected area. Marine mammals rely heavily on sound to communicate, navigate, and forage. Recent studies have found that noise from shipping, fishing, and other ocean vessels impair foraging efficiency and success in marine mammals. Numerous studies have demonstrated additional behavioral changes of marine mammals in response to exposure to noise from anthropogenic activities. These responses have ranged from subtle, short-term behavioral changes to longer-term population level impacts.

Noise can affect fish behavior, communication and, in extreme cases, cause direct tissue damage resulting in immediate or delayed mortality. Behavioral avoidance of noise can alter fish migration and schooling which can impact foraging, predator avoidance, or reproductive success.

Noise pollution also has significant impacts in terrestrial environments. Direct effects of noise to wildlife include changes in population size and decreased species diversity, decreased fecundity, altered physiology and stress response, inhibited cognitive performance, and even increased mortality. Noise can also lead to behavioral disturbance and altered habitat use patterns. For example, noise has been documented to reduce the foraging efficiency of some species and alter the singing behavior of birds. Various human recreation activities are associated with different levels of noise and may elicit strong avoidance responses from wildlife. Noise from OHV riding may reach noise levels that cause hearing loss in animals, interfere with their ability to detect predators, and disrupt life-history patterns

OREGON'S EXISTING FRAMEWORK FOR POLLUTION MANAGEMENT

Legislative and regulatory policies, strategies, and actions are necessary to prevent, reduce, and mitigate pollution and pollution impacts. Due to the wide diversity of pollution impacts and the range of spatial scales at which they occur, management and remediation are needed at local, state, national, and international levels. A number of existing frameworks guide pollution management in Oregon, including both federal- and state-level policies. While policies are in place to prevent, reduce, and mitigate impacts from many pollutants, including fossil fuel emissions, oil, and industrial pollutants, other pollution sources, such as sedimentation from agricultural or timber harvest operations, lead ammunition, noise, and light are not well regulated.

Federal Regulations

Clean Water Act (CWA) – The Clean Water Act was passed in 1972 and established the basic structure for regulating discharges of pollutants into waters of the United States and for regulating quality standards.

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) - The Federal Insecticide, Fungicide, and Rodenticide Act, passed in 1996, is the federal statute that governs the registration, distribution, sale, and use of pesticides in the United States.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) - CERCLA, also known as Superfund, was enacted in 1980, and placed a tax on certain businesses in industries engaged in work with hazardous materials. The purpose of the tax was to provide funding to clean up any hazardous materials disposal sites if those businesses no longer existed.

Endangered Species Act (ESA) - The ESA, enacted in 1973, states that it is "the policy of Congress that all Federal departments and agencies shall seek to conserve endangered species and threatened species."

National Environmental Policy Act (NEPA) - NEPA, signed into law in 1970, is a federal regulation that requires federal agencies to consider environmental impacts before making decisions.

Oil Pollution Act of 1990 (OPA) - The OPA amended the Clean Water Act in 1990 to address the wide range of problems associated with preventing, responding to, and paying for oil pollution incidents in navigable waters of the United States.

Resource Conservation and Recovery Act (RCRA) - RCRA, enacted in 1976, is a federal law that regulates the disposal of solid and hazardous waste.

Pollution Prevention Act of 1990 (PPA) - PPA is a policy, implemented by the EPA, that focuses on prevention and reduction of pollution through cost-effective changes in production, operation, and raw materials use

State Regulations

Oregon Environmental Protection Act - The Oregon Environmental Protection Act is a law that directs state agencies to ensure that environmental standards under the Clean Air and Clean Water Acts in place prior to Jan. 20, 2017, remain in effect and are enforceable under state law, maintaining stricter standards of protection. This law ensures that any federal rollbacks of environmental protection do not lessen the level of protection in Oregon.

Oregon Agricultural Water Quality Management Act - The Oregon Agricultural Water Quality Management Act was passed in 1993 and is the foundation of the Oregon Department of Agriculture's (ODA) Agricultural Water Quality Management Program. The Act directed ODA to assist the industry in preventing and controlling pollution from agricultural sources.

Oregon Toxics Use and Hazardous Waste Reduction Act - The Oregon Toxics Use and Hazardous Waste Reduction Act was passed in 1989 and updated in 2005. It was one of the first laws in the nation to mandate pollution prevention planning.

Oregon Toxic-Free Kids Act - The Oregon Toxic-Free Kids Act was passed in 2015 and expanded in 2023. The goal of the act is to reduce exposure to toxic chemicals from products marketed for children.

GOALS AND ACTIONS

Goal 1. Determine the vulnerability of species and habitats to various types of pollutants at a landscape scale.

Pollution, in its many forms, can impact fish, wildlife, and their habitats at local, landscape, and global scales. Research on pollutants and their interactions with fish, wildlife, and their habitats is rapidly evolving. The complex impacts of pollution on ecosystems will need to be continually addressed as new materials and pollutants are developed or discovered, and as advancement of scientific techniques allow biologists to detect impacts of known pollutants to fish and wildlife at lower thresholds.

Action 1.1. Work with partners to increase information on vulnerability of habitats and species to pollution.

Collect and share data on the vulnerability of species and habitats to various pollutants, as well as the direct and indirect impacts of pollutants on species, to inform effective management and mitigation. For some taxonomic groups, a great deal of information is available. For other taxonomic groups, particularly amphibians, reptiles, and invertebrates, data to help inform conservation action is limited. Collaborate between state and federal agencies, tribes, non-profit organizations, and academic institutions to facilitate research to enhance the understanding of pollution impacts and to prioritize and implement conservation actions.

Action 1.2. Support long-term research on pollution trends and ecosystem responses.

Fund and facilitate long-term studies to help track pollution levels over time and assess cumulative impacts on ecosystems. Engage in continued research as novel pollutants arise or as technology advances so that effects of known contaminants can be better measured. Share data and research findings among a diversity of stakeholders, including government agencies, universities, tribes, non-profits, and community organizations. Long-term, ongoing research will provide critical insights into how various pollutants affect biodiversity and ecosystem health, enabling adaptive management strategies that respond to emerging threats and helping to inform policy decisions.

Action 1.3. Develop and implement monitoring and evaluation techniques for Species of Greatest Conservation Need and Key Habitats.

Because of the complexity of impacts and the many types of new and emerging potential contaminants, the effects of pollutants on many species are largely unknown. Even for pollutants that have been circulating for decades, effects on species are often not well understood or described. To make the most efficient use of available funding, coordinate monitoring and share results among relevant agencies, tribes, and organizations. Standardize monitoring protocols to allow for consistent evaluation of the health of vulnerable species and habitats. Ensure that monitoring and evaluation techniques establish baseline data, engage in regular assessments, and utilize adaptive management practices. By continuously evaluating the effectiveness of pollution mitigation strategies, approaches can be adjusted based on real-time data.

Goal 2: Identify, prioritize, and implement conservation strategies to avoid, reduce, and mitigate the negative impacts of pollution on fish, wildlife, and habitats.

To facilitate effective conservation, it is important to leverage existing information and resources and encourage collaboration among all organizations engaged in pollution mitigation. This will help ensure that impacts to fish, wildlife, and their habitats are assessed and considered when developing pollution management strategies and policies, and when developing and executing conservation strategies aimed at reducing pollution effects on aquatic and terrestrial ecosystems.

Action 2.1. Incorporate currently available information into management plans for species and habitats.

The understanding of the varied impacts of contaminants on fish, wildlife, and their habitats is imperfect and constantly changing as new pollutants emerge and as research techniques advance. However, uncertainties in the understanding of pollutant impacts to specific species or ecosystem processes should not prevent active management and mitigation. Instead, leverage the best available information to integrate data and findings into existing management plans. Regularly review and update management plans to include information on pollution impacts, ensuring that conservation strategies are evidence-based and responsive to current challenges.

Action 2.2. Incorporate currently available information into guidance for best practices for land use change review.

Where feasible, update policies and guidelines that relate to land use change to reflect the latest research on pollution impacts to fish, wildlife, and ecosystems. Provide land managers, rightsholders, and other interested parties with best practices that integrate pollution management into decision making processes to encourage the best outcome for fish, wildlife, and habitats.

Action 2.3. Develop regional and local partnerships to coordinate responses to pollution across political, cultural, and jurisdictional boundaries.

Pollution and the impacts of contaminants on species and ecosystems do not follow geopolitical boundaries, which greatly increases the importance of working both within and outside of traditional boundaries to more effectively manage and mitigate pollutants. Establish collaborative partnerships among various agencies, tribes, community organizations, nonprofits, and other groups. Foster coordinated approaches to addressing the multifaceted challenges posed by pollution. This action emphasizes the importance of sharing data, resources, knowledge, and strategies across different regions and jurisdictions, ensuring a more unified and effective response to environmental issues that affect fish, wildlife, and habitats.

ADDITIONAL RESOURCES

What to Do When You’ve Had a Spill: https://www.oregon.gov/deq/Hazards-and-Cleanup/Documents/WhatToDoSpill-En.pdf

DEQ File a Pollution Complaint: https://www.oregon.gov/deq/get-involved/pages/file-pollution-complaint.aspx

Rodenticide alternatives: https://www.audubon.org/magazine/january-february-2013/poisons-used-kill-rodents-have-safer

North American Non-Lead Partnership: https://nonleadpartnership.org/

EPA Toolbox for Ecological Risk Assessment: https://cfpub.epa.gov/ncea/risk/ecobox/ecoToolSearch.cfm

National Wildlife Research Center Chemical Effects Database: https://www.aphis.usda.gov/national-wildlife-programs/nwrc/chemical-effects-database

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WATER QUALITY AND QUANTITY

CMP Direct Threats 7.2, 9, 11.3, 11.4, 11.5

BACKGROUND

Oregon's waters provide a wide range of ecological, economic, cultural, and spiritual benefits. Ample clean water is critical for meeting the basic needs of organisms, like drinking water, and for supporting Oregon's economy through irrigated agriculture, commercial fishing, industrial uses, recreation, and tourism. Healthy watersheds provide critical habitat and ecosystem services such as water purification, flood regulation, and carbon sequestration. Freshwater habitats contain significant biodiversity and support Oregon's iconic fish and wildlife species. Unfortunately, water quality and quantity are degraded or declining in many watersheds around the state and the ability of these freshwater systems to meet both human and ecosystem future needs is at risk.

Humans have greatly modified freshwater systems by diverting water out of streams and damming, channelizing, or otherwise altering waterways to store water or prevent flooding. In combination with broadscale land use change, humans have degraded some Oregon watersheds to the point that they no longer function properly nor provide the ecosystem services they once did. Unnaturally low summer water levels due to diversions can lead to reductions in available aquatic habitat, warmer stream temperatures, increased pollutant concentrations, and more frequent toxin-producing algae blooms. Elevated water temperatures and reduced stream flows also increase susceptibility and distribution of fish pathogens.

The changing climate, including shifting hydrographs and increased demands on our limited water supply, puts additional pressure on Oregon's already stressed ecosystems. Oregon's changing climate is expected to impact watershed health, hydrology, and water quality. This includes changes in precipitation patterns, air and water temperature fluctuations, shifts in snowmelt timing, and the increasing frequency of extreme weather events like floods, droughts, and wildfires (**National Climate Assessment Report for the Pacific Northwest**, the **Oregon Climate Assessment Report**). The droughts of the early 21st century have heightened awareness of the water quality and quantity implications of climate change. Ensuring sufficient amounts of high-quality water is available for aquatic ecosystems is a top concern for natural resource managers in western states facing the impacts of **climate change** and increasing water demand stemming from population growth.

Limited water supply intensifies concerns about water quality. When too much water is removed from a waterbody for out-of-stream uses, there is often not enough water remaining of sufficient quality to meet and maintain species' habitat needs. In some cases, streams can dry up completely seasonally due to a combination of natural seasonal low flows and water extraction. Summer water temperatures are typically inversely correlated with streamflow where low flows equate to high water temperatures. As streamflow declines due to diversions, groundwater pumping, and droughts, the impact of solar radiation on water temperature increases, often resulting in water temperatures elevated above species' tolerances. This can be especially problematic during summer if cold-water species do not have access to cold-water refugia and temperatures rise to lethal levels in many parts of a stream.

Water quality is an important issue for all Species of Greatest Conservation Need (SGCN). For example, water quality issues in the Klamath Basin Wetlands, Lake Abert, Malheur Lake, and Summer Lake place an entire network of migratory bird habitats at risk. Additionally, elevated summer water temperatures impact juvenile rearing and over-summering conditions for many listed anadromous salmonids in the Columbia Basin. Indeed, throughout the Pacific Northwest, watershed health is directly related to healthy populations of migratory salmon and other native fishes and in Oregon, many measures of ecosystem performance, water quality, and watershed health have been linked to native salmonid populations.

OREGON'S INTEGRATED WATER RESOURCES STRATEGY

Oregon's statewide **Integrated Water Resources Strategy** (IWRS), adopted in 2012 and last updated in 2025, provides a blueprint to help the state better understand and meet its water needs, instream and out-of-stream, above and below ground, to achieve a secure water future for people and the environment. The strategy identifies a number of objectives and critical water-related issues that need to be addressed and offers recommended actions.

The **Oregon Water Resources Department** (OWRD) and ODFW work closely together to meet the goals of the IWRS. Many of the actions identified in the State Wildlife Action Plan relate directly to actions identified in the IWRS, examples of which are highlighted in this section. Both efforts call for actions to:

- prevent and eradicate **invasive species**
- protect and restore instream flows, habitat, and **access for fish and wildlife**
- Incorporate land use changes and population growth in water planning activities
- address future **climate conditions**

WATER QUALITY

Water quality standards are developed for individual parameters to protect beneficial uses of a water body such as fish and aquatic life, recreation, water supply, and agriculture. Water quality is measured through physical, chemical, and biological parameters including temperature, dissolved oxygen, pH, and turbidity (levels of fine suspended sediments and other particulate matter). In general, increased temperature, low dissolved oxygen, or high turbidity can indicate that water quality may be degraded and uses may not be fully supported. Both point and nonpoint source pollution, including toxic contaminants, mercury deposition, bacteria, and nutrients, can degrade water quality. A key component of water quality standards are anti-degradation provisions, which include the designation of Outstanding Resource Waters (ORWs). Outstanding Resource Waters may be designated for a variety of reasons, including high water quality, exceptional recreational or ecological significance, or critical habitat.

A major tool in identifying and prioritizing water quality problems is Oregon DEQ's **Integrated Report** (published every 2 years) and list of impaired waters required under the federal Clean Water Act. This list of water bodies and stream reaches that do not meet water quality standards is updated approximately every two years.

The Oregon Water Quality Index (**OWQI**) is another method for quantifying water quality conditions using data from a network of 160 river and stream sites across the state. The OWQI is used to communicate information on the overall water quality of Oregon's rivers in an easy-to-understand, non-technical manner. Water Quality Index scores range from 10 (poor water quality) to 100 (ideal water quality) and consider dissolved oxygen, biological oxygen demand, pH, ammonia and nitrate nitrogen, phosphorous, total solids, and bacteria levels. However, additional information is required to assess impacts to human health, ecological health of aquatic systems, and the potential impacts of degraded water quality on fish and wildlife.

Oregon's Existing Framework For Water Quality

State agencies that manage major water quality programs include DEQ, ODA, ODF, and ODFW.

Oregon Department of Environmental Quality – Water Quality Programs

Oregon DEQ is responsible for protecting the state's surface waters and groundwater to keep them safe for a wide range of uses, such as drinking water, recreation, fish habitat, aquatic life, and irrigation. DEQ's water quality focus areas include:

- developing water quality standards
- monitoring and assessing water quality
- regulating sewage, industrial discharge, and injection systems
- permitting septic systems

- working with public drinking water systems
- providing grants and technical assistance to reduce nonpoint source pollution
- providing loans to communities to build treatment facilities

DEQ develops Total Maximum Daily Loads (TMDLs) as a primary approach to address water quality impairments. A TMDL is the calculated pollutant amount that a waterbody can receive and still meet water quality standards. Per an agreement with the EPA, the majority of TMDLs are prepared by DEQ and approved by the EPA for waterbodies in Oregon identified as water quality-limited and needing TMDLs (the 303(d) list). In 2022, the Oregon Environmental Quality Commission adopted rule amendments to allow TMDLs to be adopted by rule, in addition to issue by order.

TMDLs are waterbody-specific and consider seasonal variation of pollutants. They identify significant sources of pollution and then establish load allocations (portions of loading capacity to be allocated to existing nonpoint sources), wasteload allocations for point sources, and reserve capacity for the waterbody. Load allocations assigned to nonpoint sources in TMDLs are typically much lower than the current contributions of nonpoint sources to water pollution, particularly for bacteria, nutrients and temperature. Wasteload allocations are implemented through revisions to effluent limits in permits. Because they are waterbody-specific, TMDLs consider individual basin hydrography, climate, streamflow, dam and reservoir operations, land use and ownership, and local fish and wildlife. Successful implementation of TMDLs includes issuing discharge permits that incorporate appropriate wasteload allocations and developing and implementing TMDL implementation plans as identified in the Water Quality Management Plans. The DEQ has developed guidance for state and local government designated management agencies and responsible parties for developing and implementing TMDL plans within their jurisdiction.

Oregon Department of Agriculture – Water Quality Plans and Rules

The Agricultural Water Quality Management Act was passed in 1993 and is the foundation of the ODA Agricultural Water Quality Management Program. ODA, in conjunction with local stakeholders, completed 38 basin-specific agricultural water quality plans throughout the state to identify goals, objectives, and recommended management practices for agricultural landowners to improve water quality. The plans are updated every two years and include area-specific rules that require certain conditions to be met by law on all agricultural lands. Basin-specific plans and rules provide for tailoring to local conditions and needs. Plans and rules address controlling sources of pollution from agricultural lands, including erosion and sediment transport control, animal waste management, nutrient management, irrigation water management, and riparian area management. Plans and rules focus on voluntary outcomes, allowing landowners to choose the best practices for their operation to comply with the rules. Although compliance with the rules is required, the focus is on voluntary solutions rather than enforcement. To meet the goals of the plans, landowners typically work with local Soil and Water Conservation Districts (SWCDs), the Natural Resources Conservation Service (NRCS) and Farm Service Agency, and ODA to implement conservation practices.

ODA uses the Strategic Implementation Areas (SIA) initiative to address priority water quality concerns and improve streams for fish and wildlife. Through the SIA process, ODA along with other state agencies, local partners and stakeholders coordinate expertise, funding, and resources to improve water quality throughout Oregon. The SIA approach includes evaluating conditions on agricultural lands, engaging landowners to address water quality concerns on their land, and monitoring to effectively evaluate outcomes.

Oregon Department of Forestry – Water Quality Programs

The Oregon Department of Forestry (ODF) manages state-owned forestlands in Oregon and administers the Forest Practices Act (FPA) on non-federal forestlands to ensure that water quality and resource protections are maintained during and after commercial forest operations.

Forests are an integral part of the water cycle in Oregon. Forest soils filter out substances such as mercury, pesticides and other pollutants as water passes through the forest ecosystem. Forest cover slows down erosion and delays the release of water into streams, helping to stabilize the quality and quantity of water in the area. The Private Forests and State Forests divisions ensure high water quality around the state by enforcing statutes and rules that protect drinking water and fish habitat from unnecessary human-caused impacts. ODF also conducts research and monitoring to verify that current forest management practices, and any new rules or policies, maintain water quality and fish habitat.

The Private Forest Accord (PFA) is an agreement between Oregon’s timber industry, the Oregon Small Woodlands Association, and prominent conservation and fishing organizations to modify portions of Oregon’s forest practice laws and regulations in a way that expands protections for fish and amphibians while also providing regulatory certainty for timber harvest and forest management. The changes to the Oregon Forest Practices Act are aimed at avoiding and minimizing effects of timber harvest and other private forest management activities on certain aquatic species and their habitats.

Updated Forest Practice Act rules associated with the Private Forest Accord agreement include:

- Increase stream buffers and enhance protections for streams.

- Create new design standards for forest roads including new requirements to inventory, maintain, and manage roads. Associated funds will be available to replace culverts on fish bearing streams and improve roads for small forestland owners.
- Retain more trees on steep slopes to improve slope stability, reduce sediment delivery to streams, and provide long-term fish habitat.
- Protect fish and amphibian habitat. Wider stream buffers will protect water quality and habitat for stream-dependent species such as salmon, steelhead, bull trout, and amphibians.
- Modify Oregon Department of Fish and Wildlife (ODFW) regulations for managing beavers.
- Invest in compliance monitoring to better evaluate landowner compliance.
- Set up an Adaptive Management Program to inform the Board of Forestry as it determines whether to adjust rules to meet the goals of the PFA Habitat Conservation Plan (HCP). The program includes a committee and independent research and science team to give science-based and technical information to help the Board of Forestry.
- Allocate funds to conduct rulemaking, update maps and databases, monitor forest practices, and administer the laws and programs.

Oregon Department of Fish and Wildlife Programs

The Water Program at ODFW participates in agency rulemaking processes, grant reviews, water use permit reviews, water quality management planning and implementation, and other relevant processes with state and federal agencies that have a regulatory nexus to water quality to ensure decisions account for fish and wildlife needs.

Poor water quality is a major limiting factor in the recovery of many salmonid populations. For example, the Upper Willamette Chinook and Steelhead Recovery Plan identifies temperature and toxic contaminants as limiting factors for recovery. Elevated water temperatures result in reduced juvenile survival and growth, as well as higher pre-spawn mortality.

Review of mosquito abatement plans (i.e., pesticide use plans) falls under ODFW's jurisdiction. ODFW seeks to minimize effects on fish, wildlife and their habitats while not significantly interfering with disease prevention and containment. ODFW considers mosquitoes to be an important part of the ecosystem, as they provide a prey base for many of Oregon's native fish and wildlife during critical life stages, and natural predators of mosquitoes include many birds, bats, fish, amphibians, and insects. State statutes ORS 452.140 and ORS 452.245 direct vector control districts and counties to obtain ODFW approval before applying pesticides to control vectors. ODFW implements the statutes by reviewing and approving vector control plans annually. The approval process is described in ODFW's Vector Control Guidance for Sensitive Areas.

ODFW guidance contains recommendations to avoid direct impacts of pesticide applications on fish, wildlife, or their habitats, as well as attempting to minimize indirect, chronic, and long-term impacts. ODFW's approval only applies to defined and identified sensitive areas and species. ODFW has identified three categories of sensitive areas for the purposes of the guidance: 1) Wildlife Areas and Refuges, 2) Wetlands of Concern, and 3) Unique, Rare, or Vulnerable Habitats. Maps of these sensitive areas are available on the ODFW website.

WATER QUALITY: GOALS AND ACTIONS

Goal 1: Protect, maintain, and restore water quality in surface and groundwater to support a healthy ecosystem, support aquatic life, and provide fish and wildlife habitat.

Action 1.1. Reduce runoff pollution.

In urban areas, increase cooperation between governments, watershed councils, and businesses to reduce impervious surfaces and direct runoff to water bodies. When constructing new roads, consider sediment catchment and removal in road design. Promote and permit "green infrastructure" that reduces runoff, such as disconnecting downspouts, installing green ("living") roofs, and using permeable paving materials. Manage stormwater to minimize transfer of contaminants to streams. Restore riparian vegetation buffer strips and use native landscaping (e.g., ODFW's Naturescaping) and bioswales to filter runoff. Continue ongoing water quality assessments and restoration programs.

In rural and agricultural areas, reduce erosion and transport of excess sediment into streams, for example, from gravel roads and other disturbed ground. Use conservation and best management practices such as no-till or conservation tillage, plant cover crops, maintain vegetated buffer strips between fields and waterbodies, restore healthy native riparian areas, cover and store animal waste in protected upland areas, provide off-channel watering for livestock, and keep livestock out of streams.

Action 1.2. Maintain and restore wetlands, floodplains, and riparian areas to increase filtration of sediments and contaminants, mitigate flood impacts, provide shade, prevent channel erosion, recharge groundwater aquifers, and maintain stream habitat features.

Restore wetlands and riparian areas to remove and prevent contaminants from entering surface water. Avoid removal of riparian vegetation and plant trees in riparian areas to maintain stream shade, mitigate stream temperature increases, and provide critical nutrients and forage for macroinvertebrates and the stream ecosystem. Implement stream restoration techniques that improve floodplain hydrologic connectivity and increase water storage capacity. Add wood to streams to improve channel stability and complexity, slow water movement, improve aquatic habitat, and increase resilience to both low and high flows. Reconnect stream channels to floodplains and maintain native plant species in riparian areas and wetlands to help to reduce flooding intensity. Restore native vegetation throughout the watershed to increase shade and reduce stream temperatures, maintain water infiltration and flow, prevent soil erosion, and prevent contaminants from entering aquatic systems.

Action 1.3. Implement water quality improvement projects and management frameworks.

Use incentive programs, such as tax credits, pollution credits, and other tools to reduce the amount of contaminants entering waterways. In urban areas, continue educational efforts, such as "Dump No Waste – Drains to Stream" postings at sewer drains. Continue implementing DEQ's TMDL planning and ODA Water Quality Management planning, which address water quality on a watershed basis, including nonpoint sources of contaminants. Manage for water quality within an adaptive management framework that incorporates new information and responds to emerging concerns. Consider water quality implications of water resources infrastructure (e.g., reservoirs) and develop management plans that ensure compliance with water quality standards.

Action 1.4. Monitor chemical, physical, and biological parameters of aquatic habitats for changes in water quality and to identify high quality and impaired waterbodies.

Promote statewide long-term water quality and quantity monitoring efforts, including for emerging contaminates (e.g., 6PPD-q). Incorporate national and regional program water quantity and quality indicators to assess ecological function (i.e., US Environmental Protection Agency, National Research Council, OR DEQ). Use of indicators can help characterize the status of waterways to better detect change and to diagnose the causes of change.

Examples of biological indicators include:

- Macroinvertebrate community indices (e.g., Multimetric Index, Observed/Expected ratio)
- Macroinvertebrate species richness, number of native taxa, relative abundance of sensitive taxa, biomass, productivity

- Salmonid population, structure, abundance, productivity, diversity
- Species interactions, including predation, competition, presence of invasive species

Examples of chemical indicators include:

- Nutrient levels
- Chlorophyll A/cyanotoxins
- Presence of specific toxic contaminants
- Mercury

Examples of physical indicators include:

- Water clarity
- pH
- Temperature
- Dissolved oxygen
- Total suspended solids

Guidelines for sampling protocols and methodology can be found through the DEQ and the U.S. EPA. Indices can be linked to specific stressors (Stressor ID) using a weight of evidence approach that combines existing data, literature, and scientific judgment to make predictions about ecological characteristics.

Identify Oregon's cold-water refugia by continuing water temperature modeling and data collection efforts statewide. Work with other state agencies to identify approaches and implement protections for the state's most critical cold-water resources.

WATER QUANTITY

Under Oregon law, water is a public resource, meaning that all water belongs to the public. With some exceptions, cities, irrigators, businesses, and other water users must obtain a permit or license from the Oregon Water Resources Department (OWRD) to use water from any source whether it is underground, or from lakes or streams.

In many areas of the state, particularly during the summer, water supplies are fully allocated to out-of-stream uses (e.g. irrigation), reducing flows to the point that they no longer provide quality habitat for Oregon's fish and wildlife. Water is diverted out of rivers, streams, aquifers, and lakes for uses such as agriculture, municipal, industrial, domestic, and power generation. Other physical alterations affecting flow and habitat access include natural and artificial barriers, wetland drainage, or channelization. The timing of water diversions and releases influence disturbance regimes, sediment and bedload transport, and groundwater storage and discharge. For example, the timing, location, and quantity of water released from dams can have negative or positive implications on available habitat and water temperature. Unnatural water fluctuations can impact fish and wildlife by altering the timing of fish migrations, dewatering fish eggs, or stranding fish in isolated pools. Increased groundwater pumping reduces groundwater discharge of cold water to rivers and streams, subsequently reducing the availability of both cold water refugia and suitable habitat for cold-water dependent species. Global processes, including **climate change**, influence temperature and precipitation patterns and can potentially affect runoff amounts and timing, aquifer recharge, and water supplies. Increasingly frequent multi-year droughts can have severe implication on water quantity as well as quality and can have long-term impacts that persist after the conclusion of official drought (e.g., reservoir refilling).

In Oregon, state agencies, including ODFW, DEQ and the Oregon Parks and Recreation Department, can apply for instream water rights for the benefit of the people of the state of Oregon to legally protect water instream (e.g., within a stream channel or lake bed) for public uses such as fish and wildlife, water quality, and recreation (adapted from the **Instream Water Rights Act of 1987**, ORS 537.332 – 537.360). Instream water rights are the state's mechanism to provide water for healthy ecosystems that support multiple public uses by protecting the full suite of flows for fish and wildlife, water quality, recreation, and scenic attraction, as well as supporting cultural values and healthy economies. OWRD is the state agency responsible for protecting instream water rights in trust to support the public interest. ODFW applies for instream flows based on estimated monthly requirements to sustain healthy fish populations. Instream Water Right Rules (OAR 635-400) set the policy for ODFW's instream water right applications, which are intended to protect flows instream for aquatic and fish life, wildlife, and their habitats. ODFW's policy is to apply for instream water rights on waterways of the state to conserve, maintain, and enhance aquatic and fish life for present and future generations of Oregonians. The long-term goal of this policy is to obtain an instream water right on every waterway that has value to fish and wildlife.

ODFW and OWRD developed streamflow restoration priority maps showing flow restoration needs and priorities. The maps display each river basin, with rankings for streamflow restoration need, feasibility for streamflow restoration, and priorities for restoration. These prioritization maps and additional information, including a summary of the prioritization process and the criteria used to establish the priorities, are available in the **ODFW Data Clearinghouse**, with summer priorities provided as a layer within the **ODFW Compass mapping tool**. ODFW has also developed a tool to identify Aquatic Habitat Prioritization for flow protection and restoration.

WATER QUANTITY: GOALS AND ACTIONS

Goal 2: Conserve, protect, maintain, and restore surface flows and groundwater levels to support healthy SGCN and Key Habitats. Seek opportunities to conserve, maintain, and restore streamflow and lake levels, as well as groundwater and spring-fed ecosystems that provide cold water refugia for SGCN.

Action 2.1. Work with agencies, tribes, conservation groups, water users, and other organizations to establish priorities, develop tools, and implement projects that maintain, protect, or restore stream flows.

Conduct instream flow studies to develop ecological flow targets and apply for associated instream water rights. Identify and protect the state's cold-water resources. Conduct real-time flow and temperature monitoring in priority areas. Identify priority locations for instream transfers and leases and other voluntary flow restoration efforts. Work with water users and conservation groups to actively restore streamflow in priority areas using voluntary market-based agreements. Promote water management actions that enable climate resilience and adaptation. Engage with regulatory agencies to ensure consideration of fish and wildlife needs in water right and hydropower processes. Continue to develop methods to determine if sufficient water supplies exist to maintain ecological functions that support **SGCNs**, and further identify when conservation actions may be needed. Protect stream flows from further decline in areas not meeting fish and wildlife habitat needs. Collaborate with ongoing water quantity efforts taking place under the Oregon Plan (Oregon Watershed Enhancement Board). Further collaborative water planning and implementation processes to secure balanced solutions for water management (e.g., water markets, water banks, and incentive programs). Engage local communities, stakeholders, and tribes in watershed management decisions to understand the value of traditional knowledge, foster partnerships, and ensure that management plans are inclusive and equitable. Use voluntary conservation tools, such as the **Allocation of Conserved Water Program**. Work with OWRD to ensure instream water rights are adequately monitored and protected, when appropriate, instream. Identify and protect cold water rearing and refugia habitat for SGCN (e.g., Cold Water Refugia and Core Cold Water Habitat Use designations by Oregon Department of Environmental Quality)

Action 2.2. Maintain and protect groundwater and seek opportunities to enhance aquifer recharge.

Protect aquifers from further decline. Seek opportunities to support aquifer recharge that restores groundwater to sustain surface flows and groundwater-dependent ecosystems. For example, restore floodplain function and restore **wetlands** to allow for greater water infiltration. Continue implementation of Oregon’s Groundwater Quality Protection Act, implemented by DEQ.

Action 2.3. Use established indicators to monitor watershed function and determine thresholds for action.

Monitor water quantity and quality to better understand watershed function and processes and guide restoration. Promote expansion of real-time water quantity and quality monitoring gage network throughout the state. Incorporate integrated hydrologic and water quality models, habitat equivalency and net environmental benefit models, and use habitat characteristics to predict ecological changes that might result from proposed hydrologic alterations. Use the existing indicators for watershed health, to measure ecological function. These indicators include:

- altered hydrology
- floodplain presence and connectivity
- groundwater availability
- riparian condition (e.g., width, composition, fragmentation)
- stream connectivity
- channel condition
- habitat structure (e.g., habitat types, bank erosion, channel substrate, off channel habitat, large wood).

Continued use of these indicators, along with actions to address watershed function issues, will ensure that watersheds provide vital ecological services to humans, fish, and wildlife.

ADDITIONAL RESOURCES

Oregon’s **Integrated Water Resources Strategy** was adopted by the Water Resources Commission in August 2012 and last updated in 2025. As one of the supporting agencies and a member of the IWRS Project Team, ODFW supported the inclusion of instream needs, including water quality, water quantity, and ecosystem needs.

The National **Climate Assessment**, 2018: “Significant changes in water quantity and quality are evident across the country. These changes, which are expected to persist, present an ongoing risk to coupled human and natural systems and related ecosystem services. Variable precipitation and rising temperature are intensifying droughts, increasing heavy downpours, and reducing snowpack. Reduced snow-to-rain ratios are leading to significant differences between the timing of water supply and demand. Groundwater depletion is exacerbating drought risk. Surface water quality is declining as water temperature increases and more frequent high-intensity rainfall events mobilize pollutants such as sediments and nutrients" (Chapter 3: Water, Key Message 1: Water Quantity and Quality).

Willamette Water 2100: **This project** evaluated how climate change, population growth, and economic growth would alter the availability and the use of water in the Willamette River Basin on a decadal to centennial timescale. The five-year project began in October 2010 and was a collaborative effort of faculty from Oregon State University, the University of Oregon, and Portland State University, and was funded by the National Science Foundation. The project developed tools to help foster understanding of water scarcity and inform water system management.

DEQ's **Water Quality Trading Program**

Department of State Lands **Mitigation Guidance**

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