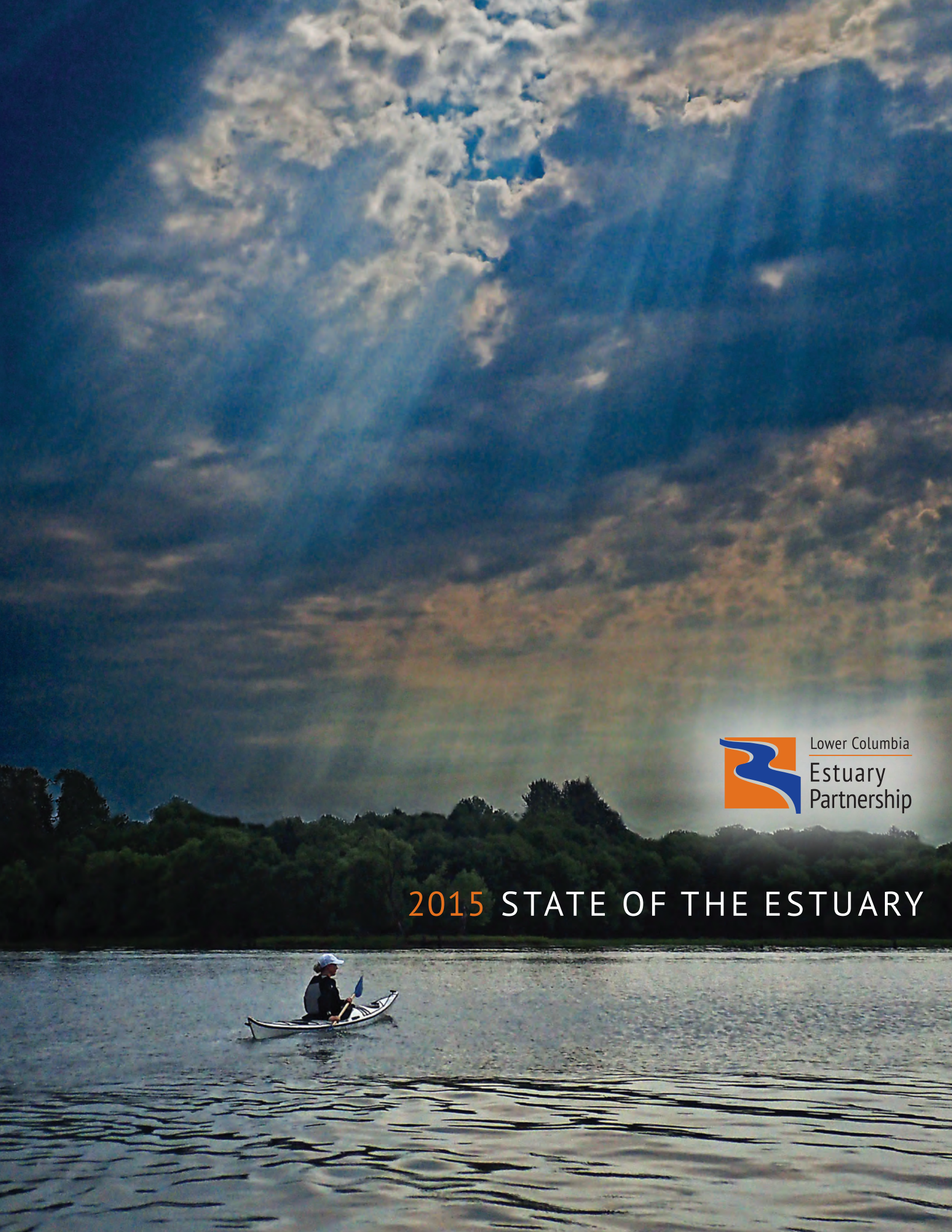
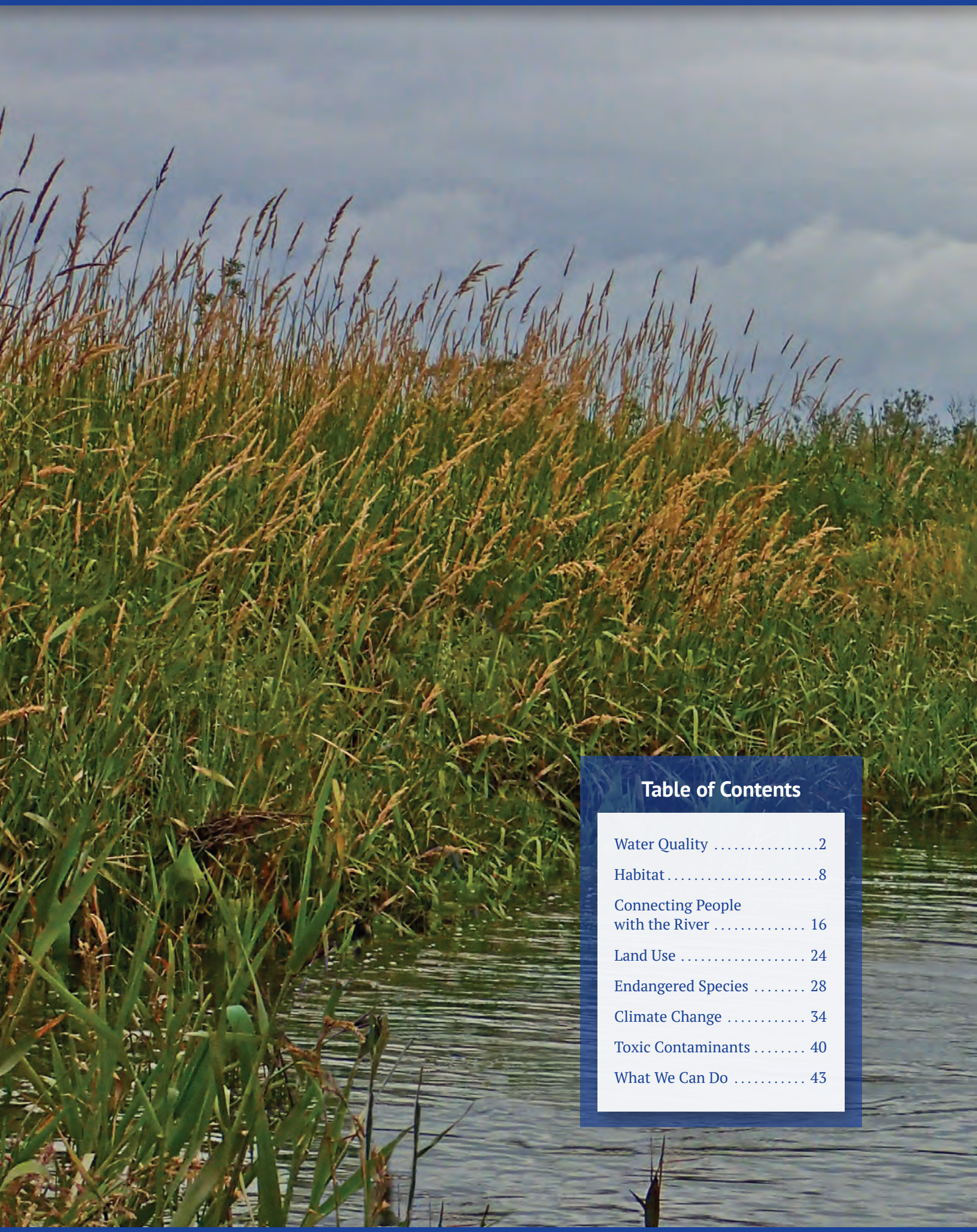


Lower Columbia
Estuary
Partnership

2015 STATE OF THE ESTUARY



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2015 marks a milestone for the Estuary Partnership—our 20th anniversary.

The States of Oregon and Washington and US Environmental Protection Agency (US EPA) created the Estuary Partnership to engage the community to address degradation in water quality and habitat loss. They asked for an inclusive process that focused on on-the-ground results. We dedicated our Management Plan to our children and the seventh generation of our children's children. It keeps us focused on what matters and is our common bond. Our founders had remarkable vision.

Every five years, we report on the state of the lower Columbia River and estuary. This is our third report. We have many successes, and there are challenges ahead.

The progress we have made since 1995 is notable, the result of work by many public and private partners throughout the region. Federal agencies, state agencies, tribes, businesses, growers, teachers, landowners, students, conservation groups, and community volunteers have all come together and collaboratively shared the responsibility to care for the Columbia River. Each has made a significant investment.

Looking forward, climate change and toxics are two increasing threats to the river, public health, and the vitality of our communities. We will need a heightened focus on both.

Toxics are ubiquitous in the Columbia River Basin. They impact plants, animals, our families, our economy and our quality of life and they come from many sources, including agriculture, wastewater, and urban runoff. These toxics can accumulate up the food chain and pose significant threats to human health.

We know what we need to do to reduce toxics and we are making some progress. We just need to do more. Current funding levels cannot address this significant threat to the Basin – the problem is too large, comes from too many sources, and needs major federal investment and attention.

The Estuary Partnership is working with Congress to pass the Columbia River Basin Restoration Act to help reduce toxics. It is long overdue; investments to reduce toxics in the Columbia Basin lag far behind other major water bodies designated by US EPA.

We are now living with a changed climate and more changes are ahead. There are many things we can do now to adapt and mitigate for what has already occurred. We can restore or protect sources of cold water for cold water species. We can expand data and fill key information gaps on specific climate change impacts to the lower Columbia River and estuary. For example, there is no assessment of predicted sea level rise in the Columbia above river mile 37. Research is critical if we are to make investments that will recover and repair damage we have already sustained and avoid future damage.

Toxics and climate change will require us to act differently toward environmental protection; we will have to take action now based on projected impacts, not just assessed degradation. Letting damage occur and expecting we can recover from it is not the right approach. It is too costly, it allows the impairment or loss to occur – whether it's toxic exposure or rebuilding in floodplains – and the projected impacts are too extensive. We need to anticipate the impact and change many past and current practices, including where we build and what we allow into our ecosystem. The strong partnerships and successes realized over the past twenty years position us well to address these threats together.

Debrah Marriott
Executive Director

Water Quality

Is water quality getting better or worse?

We aren't sure. We still don't have a complete picture of water quality in the lower Columbia River because there is no sustained monitoring. Instead, we rely on data from one-time studies conducted in various parts of the lower river. We know a lot – enough to know the story isn't good, and enough to take action, but not enough to track changes over time or understand the full impact.

We know that temperature and dissolved oxygen sometimes are at levels that threaten survival of aquatic organisms. Toxic contaminants are present in the water, sediment, prey species, salmon, and other fish and wildlife. Some pesticides (DDT) and polychlorinated biphenyl (PCBs) are highly persistent and remain in the estuary for a long time. Flame retardants (PBDEs) and ingredients in personal care products are posing additional risk to sensitive ecosystems and to human health.

In the past five years, water quality monitoring along the mainstem Columbia River has been minimal. The US EPA, States and others have had success collecting unused pesticides and pharmaceuticals. Voluntary partnerships with many businesses are seeing reduction in use of toxics. Climate change impacts are being felt, notably in water temperatures.

If we are to improve water quality, we need to address issues like temperature and dissolved oxygen and learn more about toxic contaminants, where they are, where they are coming from, how they move through the system, how their levels are changing over time, and what their individual and synergistic impacts are on all species. We also will need to better understand the impacts of climate change on water temperatures in the lower Columbia River.

There are successes, but they are not enough, especially to address the growing impacts of toxic contaminants, and funding is inadequate to comprehensively address the issue and expand toxics clean-up and reduction efforts.

When we evaluate water quality we look at a range of conditions, from temperature, pH, dissolved oxygen, and sediment, to heavy metals, fertilizers, pesticides, flame retardants, chlorine compounds, hydrocarbons and other toxics. For this report, we focus on water temperature, dissolved oxygen and several toxic contaminants.

Water Temperature and Dissolved Oxygen. During the summer months, water temperature and dissolved oxygen in the mainstem Columbia River increasingly are at levels that threaten species survival. Since 2010, water temperatures in the mainstem have exceeded the maximum recommended temperature for migrating salmon (19°C or 66°F) for up to 80 days between late June and early September. In 2014, temperatures were above 21°C (71°F) for 42 days. In 2015, temperatures ran significantly above limits that are safe for fish, with some of the warmest water temperatures measured in the lower Columbia River in recent years. And they are having an effect: the warmer temperatures are killing returning salmon at rates higher than ever before. Elevated water temperatures result from the overall warming trend in air temperatures, reduced flows, water being held upstream in dams and diversions during warmer months, inputs of relatively warm stormwater, drought, and the loss of riparian vegetation and the shade it provides on tributary streams.

Summertime dissolved oxygen levels sometimes drop below the state-recommended threshold of 8 milligrams per liter. This is happening in both the mainstem and in backwater sloughs where juvenile salmon rear. Dissolved oxygen levels are important because salmon and other aquatic animals need oxygen to "breathe," and they get that oxygen from the water.

Dissolved oxygen levels do vary somewhat in response to changes in biological activity or temperature. (Warm water holds less oxygen than cool water, for example). But when dissolved oxygen levels drop too low, aquatic life may not be able to survive. Low-oxygen conditions are expected to occur more often in the estuary as climate change alters sea levels, tidal exchange, precipitation patterns, and river flows.

One of the best ways to address temperature and dissolved oxygen is by reforesting riparian areas along the lower Columbia River and its tributaries to shade streams during hot weather. Cooler water temperatures will also help keep dissolved oxygen levels from falling too low.

Toxic Contaminants. Toxic contaminants in water and sediment have significant deleterious impacts on aquatic life in the lower river – and human health. One-time studies that we and several of our partners have done have found PCBs, PAHs, copper, DDT and other pesticides, pharmaceuticals, and flame retardants (PBDEs) in water samples taken from multiple locations in the lower Columbia River. Toxic contaminants are found not just in the water but in sediments, fish, and wildlife, too. Concentrations vary by location; studies have found that toxic contaminant levels are higher near urban areas, which gives us a clear indication that lifestyle practices are contributing significant amounts of toxic contaminants to the Columbia River.

Some of these toxic contaminants are persistent – which means they last long in the environment (in the water and in sediment). These toxic contaminants can make their way into the food chain and bioaccumulate in the tissues of predators such as salmon, river otters, and eagles. Testing confirms that levels of PCBs, copper, and DDT are high enough in the bodies of juvenile salmon to cause health effects, and that PAHs may be at levels to cause concern. Many of those contaminants are "legacy" contaminants, meaning that their use was banned or severely restricted a long time ago, yet they persist in the environment.

We are also concerned about other contaminants, including PBDEs (flame retardants), current-use pesticides, fertilizers, and pharmaceuticals. These are present in the lower Columbia River at levels that affect juvenile salmon's hormone balance and neurologic functions. These contaminants also have been found in several other species, including humans.

What is being done?

Since 2010, the Estuary Partnership has engaged in data collection and other water quality related activities.

Ecosystem Monitoring Program. Through our Ecosystem Monitoring Program, the Estuary Partnership works with key partners (National Oceanic and Atmospheric Administration (NOAA) Fisheries, Pacific Northwest National Laboratory, U.S. Geological Survey, and Oregon Heath and Sciences University) to assess the condition and health of juvenile salmon habitat in the lower Columbia River, at various places and times, as funding allows. We have collected limited data on juvenile salmon, salmon prey, food web, and salmon habitat. Most of the studies, however, are one-time studies.

We have learned a great deal from the data collected in the region, but they can't answer questions about the sources, distribution, concentration levels or how these levels change spatially or over time.

Columbia River Contaminants and Habitat Characterization (ConHab) Study. The U.S. Geological Survey investigated how contaminants such as flame retardants and endocrine-disrupting compounds affect different levels of the food web. The study found that the concentrations of many contaminants in water, sediments, fish tissues, and osprey eggs were higher near or downstream of large urbanized areas than at test locations like the small town of Skamania located above Bonneville Dam. Results also indicate that fish at the sites downstream of large urban areas experienced more physiological stress, such as gonad, kidney, spleen, and liver abnormalities, and a higher level of parasite infections. The study showed that contaminants are bioaccumulating and probably are causing genetic mutations and reproductive impacts within the food web.

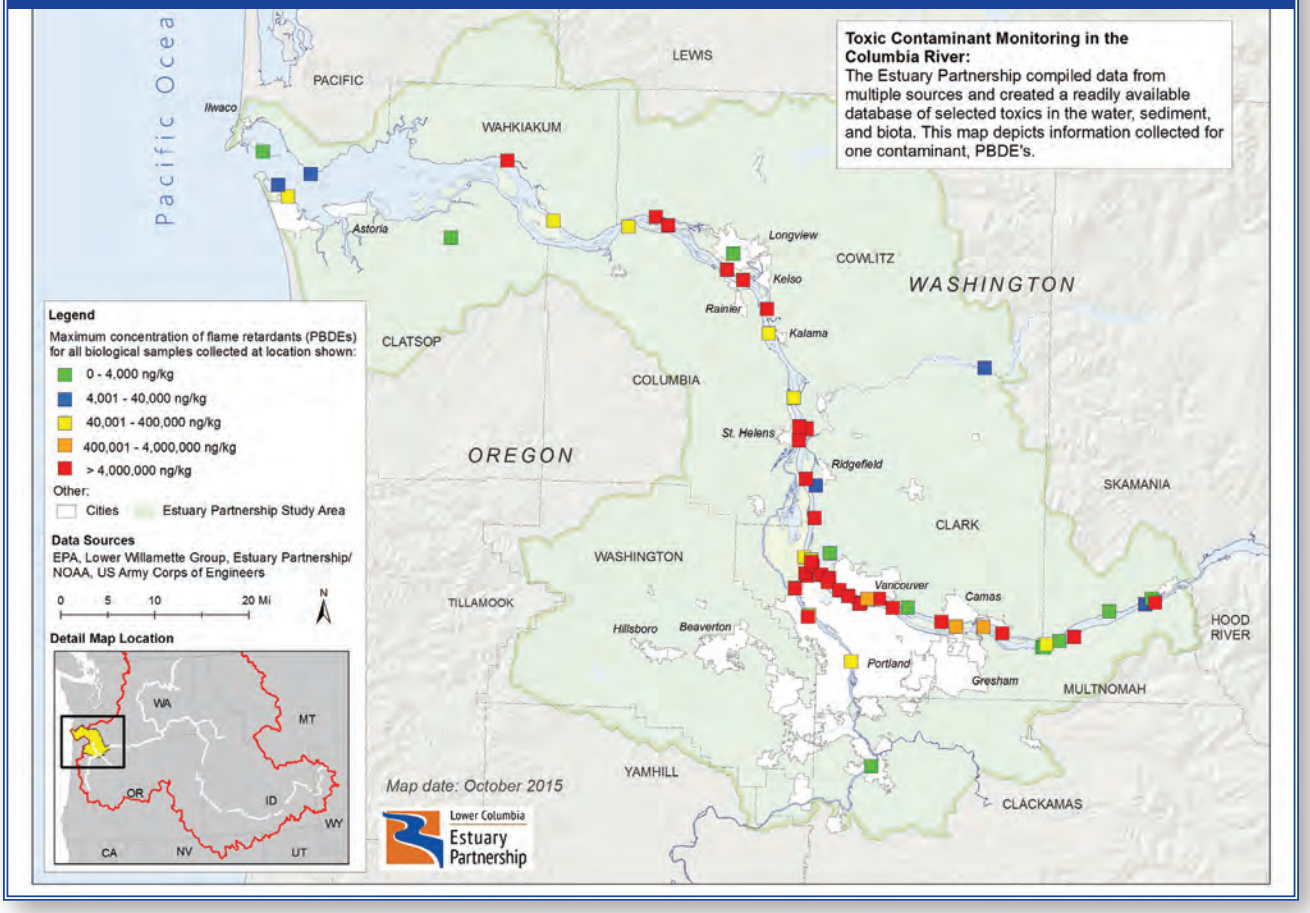
Cold-Water Refugia. The Estuary Partnership is documenting the characteristics and distribution of cold-water refugia in the lower Columbia River from the Sandy River Delta to Bonneville Dam. Cold-water refugia are the cooler spots that salmon seek out in response to warm water temperatures; often the refugia are located where tributary streams from forested watersheds empty into the Columbia River. Understanding how much cool-water habitat currently is available for migrating fish – and where it is located – will allow us to identify areas to protect and restore to help mitigate the impacts of climate change on rising river temperatures.

Toxics Summit. In 2014, the Estuary Partnership convened a Science to Policy summit where scientists, community leaders, and natural resource managers discussed the emerging science surrounding the sources and impacts of toxic contaminants in the Columbia River and shared recent contaminant reduction success stories.

Columbia River Basin Restoration Act. The Estuary Partnership has worked with Congressman Earl Blumenauer (Oregon) and Senator Jeff Merkley (Oregon) and members of Congress since 2007 to secure funds for toxics reduction activities. In 2010, they introduced the Columbia River Basin Restoration Act. Passage of the act will authorize Congress to appropriate funds to create a voluntary grant program to reduce, clean up, or eliminate toxic contaminants in the Columbia River Basin. A similar bill was introduced in 2014 and 2015.

Contaminant Database. In 2011, the Estuary Partnership compiled data on contaminants from throughout the lower Columbia River into a centralized geospatial database. The data were collected by various regional entities over several decades. We synthesized the data into a series of maps and graphs to identify "hot spots" of specific contaminants in the region, which also shows data gaps. Contaminants included pesticides, flame retardants, PAHs, metals, and PCBs and parameters were collected from biota, sediment, fish tissue, and water. The results showed high concentrations of PCBs and PAHs near the urban and industrialized areas of Portland and Longview and found legacy pesticides (such as DDT and PCBs) in biological samples and sediment throughout

Total PBDEs in Biological Samples Collected During 2000–2009



the lower Columbia River. It also highlighted the lack of data on most toxics in the lower river.

Voluntary Reduction. Many entities are voluntarily reducing their use of toxic contaminants.

State of Oregon Pesticide Stewardship Partnerships have facilitated significant voluntary reductions in pesticide application, such that some growers have reduced the pesticide drift from spraying by 99 percent.

In over just two growing seasons, growers in the Wasco County watershed reduced their use of one toxic pesticide (malathion) from eight times the water quality criterion to less than half the criterion.

In the Yakima River, irrigation districts, the Washington Department of Ecology, and the Yakama Indian Nation collaborated to reach a 20-year goal of reducing DDT in just five years, and fish consumption advisories were lifted as a result.

The commitment by agricultural producers to third-party labeling, such as Salmon-Safe, has created an international market for agricultural products that use few or no pesticides.

Collection Events. The Oregon Department of Environmental Quality, Washington State Department of Agriculture, and US EPA have hosted numerous collection events to keep toxic substances out of the region's waterways. Hundreds of thousands of pounds of DDT, other pesticides, fertilizers, and pharmaceuticals have been collected. At just one small event that the Estuary Partnership sponsored in Longview in 2012, approximately 10,000 pounds of pesticides were collected. Since 1988 in Washington state alone, 2.9 million pounds of unused pesticides have been collected from more than 7,600 customers.

State Policies and Practices. The States of Oregon and Washington have changed their practices to purchase "green" janitorial and office products; the janitorial supplies alone represent an estimated $20 million in purchasing power.

Local Government Leadership. Local governments are taking action. In 2011, the City of Portland completed a $1 billion project that reduced combined sewer overflows to the Willamette River by 94 percent. Ports are also helping. The Port of Vancouver, Washington, constructed one of the largest stormwater bio-retention facilities in the world which treats stormwater runoff from 50 acres at one of the port's five marine terminals.

Legislation. Oregon and Washington have taken steps to reduce the amount of toxic contaminants entering our waterways. The two states both have banned some flame retardants. Washington has banned lead, cadmium, and phthalates from children's products and is tracking other contaminants in those products. Oregon now requires manufacturers to disclose and phase out hazardous chemicals in consumer products targeted at children.

Columbia River Toxics Reduction Working Group. The US EPA organizes this group which includes members from federal, state, tribal, and local governments, industry, and non-profit groups. The group discusses ongoing efforts to assess and reduce contaminants across the Columbia Basin. Efforts include increasing support for voluntary reduction efforts such as pharmaceutical and pesticide take-back programs. In 2010, the working group issued an action plan for the Columbia Basin. In 2014, it developed a white paper for Measuring, Documenting and Reducing Chemicals of Emerging Concern, which characterizes the influence of contaminants of emerging concern on aquatic and terrestrial wildlife and outlines future research and monitoring plans for the Columbia Basin.

Why This Matters

Water quality matters because it affects the biological integrity of the lower Columbia River and the health of species that live in and around it—including humans.

Water temperature matters because cold-water species such as salmon and steelhead need specific temperature ranges to survive and thrive. Dissolved oxygen matters because aquatic animals need oxygen to "breath," and if levels drop too low, they may not be able to survive.

Toxic contaminants matter because organisms have specific tolerance ranges. Exposures that exceed these tolerance ranges can cause stress, impair the function of the nervous, immune, endocrine, and reproductive systems, and reduce the survival and reproductive success of species. Contaminants inhibit the recovery of threatened and endangered species.

Some contaminants bioaccumulate up the food chain. For example, when juvenile fish feed on prey, they absorb contaminants from the prey or the surrounding environment and store those toxins in their bodies. Then, as birds, mammals, and people eat the contaminated fish, toxins accumulate in their own bodies, sometimes reaching concentrations that cause adverse health effects.

Toxic contaminants matter to human health. Each year, state officials issue advisories encouraging people to limit their consumption of resident fish caught in the Columbia River watershed because of the level of toxic contaminants in the fish.

Economically, toxic contaminants matter because they affect industrial lands. Contaminated "brownfields" cannot be used until they undergo costly cleanup. Currently in the lower Columbia River, contaminated dredge materials threaten the operations of ports and marinas.

Toxic contaminants matter because their presence may counteract some of the benefits of costly habitat restoration. In general, we do not effectively evaluate potential restoration sites for toxic contaminants, so we may be restoring sites that have contaminated soils.

Challenges Ahead

Climate Change. Climate change is expected to increase the frequency and severity of low-oxygen conditions and warm water temperatures in the lower Columbia River. Additional research is needed to understand how we can best prepare for these changes.

Building Practices. As the human population grows, so too does the amount of impervious surfaces in the region—and the potential for stormwater to transport even more toxic contaminants into the Columbia River. By using green infrastructure, we can reduce the amount of impervious surfaces. If we can keep impervious surface levels below 25 percent of a watershed's area, we reduce the chance of acute degradation of stream health. Keeping toxics out of the waterways is safer and much less costly than treating it or cleaning it up.

Personal Choices and Market Demand for Products. Our personal choices about the energy we use and what we buy can help create a market for greener, low-toxicity technologies and products that do not harm water quality. But making changes in our personal habits often is challenging, especially on a large scale. We will need to drive less, use more sustainable and non-polluting energy sources, and choose products that have few or no toxics. This all creates a market for greener, low-toxicity technology and products.

Keep Learning. We have learned a great deal from what data have been collected in the region. But many questions remain about the sources, distribution, and concentrations of toxic contaminants in the lower river—especially about how toxic concentration levels and inputs are changing over time. The data collection is intermittent; there is no sustained monitoring which is needed to track changes. Data collection and analysis are key first steps to target areas for cleanup, track sources of contaminants, and identify and employ actions that will reduce contaminant levels.

Sustain Funding. Resources to fund contaminant monitoring, reduction, and clean-up efforts are needed but remain limited. Although the US EPA officially designated the Columbia River Basin as a large aquatic ecosystem in 2006, it is only one of two large aquatic ecosystems in the nation to not receive funding related to that designation. Since 2009, the other designated large aquatic ecosystems (Great Lakes, Lake Champlain, Long Island Sound, Chesapeake Bay, Gulf of Mexico/Mississippi River Basin, Lake Pontchartrain, South Florida, San Francisco Bay Delta, the Pacific Islands [also unfunded] and Puget Sound-Georgia Basin) together have received $3 billion.

Habitat

Are we protecting and restoring important fish and wildlife in the lower Columbia River?

From 2010 to 2015, restoration practitioners protected or restored 1,434 acres in the lower Columbia River and estuary. This is about two-thirds what was completed in the previous five-year period. The decrease reflects how restoration in the estuary is changing.

Over the past five years, we developed tools to address these changes. We compiled data and developed a regional prioritization strategy and classification system that help identify both the best sites and the most effective restoration techniques for each site to maximize the benefits of restoration efforts.

Most of the ready-to-go projects have been completed, and the remaining opportunities are much more complex. Historically, restoration has occurred on publicly owned lands, or on parcels owned and managed for conservation purposes. The quantity of these lands is limited. Habitat restoration will require more work with private landowners and identifying restoration techniques that improve sites for native species while at the same time meeting private landowner goals (such as farming).

This next phase of restoration will be even more challenging. Projects will be more complex and more costly. We need to include a multi-species focus in our restoration work, track habitat that we are losing, set scientifically based restoration targets, and integrate toxic contaminants assessment and climate change impacts into restoration actions.

Since 2000, restoration practitioners have protected or restored 21,399 acres of habitat in the lower Columbia River region. This is a major accomplishment, exceeding the 2010 and 2014 targets in the Estuary Partnership's Comprehensive Conservation and Management Plan and it puts the region well on its way to achieving the goal of 25,000 acres protected or restored by 2025.

Projects have included land acquisition, levee breaching, removal or replacement of tide gates and culverts, large wood placement, riparian planting, and other techniques. Hundreds of stakeholders have been involved, working together to accomplish the common goal of ecosystem restoration. A key partner on each project has been the willing landowner.

The 21,399 acres restored is less than a quarter of the 114,050 acres of habitat lost since 1870, including 70 percent of the lower Columbia River's vegetated tidal wetlands (a critical habitat type) and 55 percent of its forested uplands. Most of the lost habitat was converted to urban, industrial, or agricultural uses, and much of the associated widespread diking built to protect those uses still exists. This large-scale habitat loss has greatly reduced both the quantity and quality of habitat for the estuary's native species.

What is being done?

Since 2010, the Estuary Partnership has completed several data sets and developed tools to advance our understanding about restoration as we go forward.

Restoration Prioritization. In 2014, we completed a restoration prioritization strategy for the lower Columbia River. By identifying areas where restoration will provide the greatest ecological uplift, the strategy serves as a framework for making decisions about restoration at the landscape scale. The strategy uses multiple selection factors, or "lines of evidence," to identify areas to restore that will reap the most ecological benefit. This approach significantly improves the likelihood of success for comprehensive ecosystem restoration. Individual project decisions can be put into the context of the larger geographic region, and the complexity of the ecosystem can be accounted for in project scoping.

By using the restoration prioritization strategy, we can improve the overall success of habitat restoration in the region and invest regional funds more strategically. The US EPA provided funding to complete this strategy. This is the first time anyone has compiled multiple data sets for the entire lower Columbia to specifically identify priority areas for protection and restoration and types of restoration for those areas.

The strategy is ecosystem-based with a focus on juvenile salmon. The goal is to restore ecosystem structure and function by restoring natural habitat diversity, which will help restore diversity among salmon and steelhead populations as well as populations of other native species.

What does the strategy do?

- Allows users to comprehensively analyze the entire lower river and prioritize some areas over others for habitat protection and restoration based on the potential for greatest ecological uplift.
- Provides multiple data sets for the entire lower river to allow users the choice of which to use in making their decisions.
- Allows users to identify gaps in habitat coverage and anchor areas for large reserves.
- Integrates multi-species protection and toxic contaminant reduction into our habitat restoration approaches.

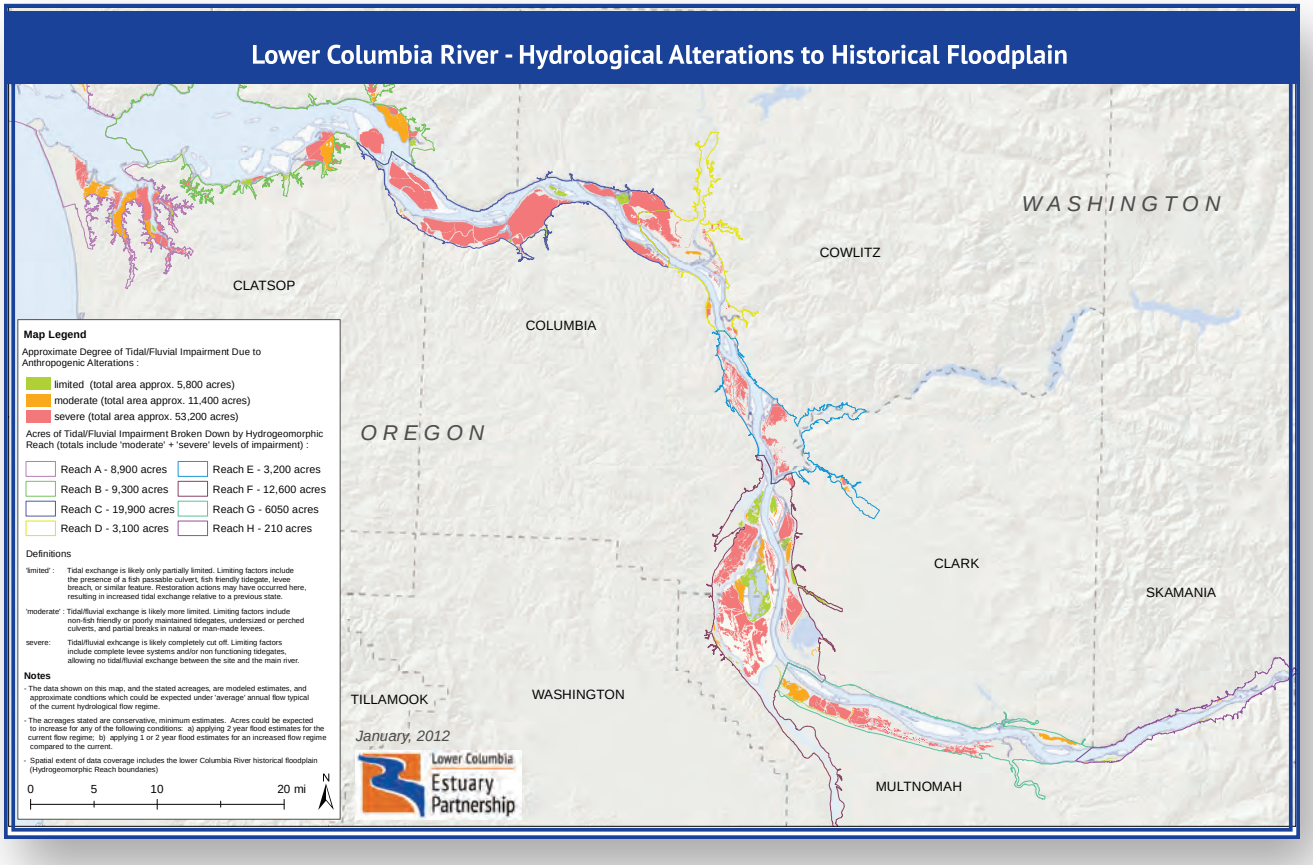
The strategy uses multiple lines of evidence or data components:

- Historical habitat change analysis (complete)
- Juvenile salmonid habitat suitability index (complete)
- Priority tributaries in Oregon and Washington salmon recovery plans (complete)
- Columbian white-tailed deer habitat (complete) (USFWS)
- Priority habitats for the Pacific Flyway (underway)
- Priority toxic contaminant clean-up sites (draft) (Yakama Nation)
- Sea level rise and inland migration of wetlands (needed)

Columbia River Estuarine Ecosystem Classification. With the U.S. Geological Survey and the University of Washington, and funding from Bonneville Power Administration, the Estuary Partnership developed a six-tiered method of classifying ecosystems in the lower Columbia River.

The classification inventories habitats and the underlying geology that provides structure for those habitats, and improves our understanding of how physical factors drive the evolution of the estuary's various habitats. The data in the classification drive restoration to projects that will have the most ecological uplift.

Historical Habitat Change Analysis. In 2011, we completed a historical habitat change analysis comparing land cover data from late 1800s-era historical maps to our 2010 land cover data set. The results show where critical habitat types, such as tidal wetlands, have been lost and gives us an idea of the natural habitat diversity that used to exist. The comparison tells us the severity, type, and quantity of habitat loss, and what the habitat has been converted to or other land uses.



Quantifying changes in habitat allows us to prioritize which habitats should be recovered and/or protected and provides a basis for setting recovery targets.

Native species evolved with historical habitat conditions; restoring something that is representative of those conditions will aid recovery and protection of those species.

Recoverable Areas. Using the ecosystem classification and the prioritization strategy, the Estuary Partnership identified 77,210 acres in the lower Columbia as "recoverable." This means that the land uses currently there are low-impact and could be restored with willing landowners. Within the recoverable areas, we identified priority habitat types for restoration, based on the severity of loss for an individual habitat, and where to focus that restoration, based on the historical distribution of the priority habitats.

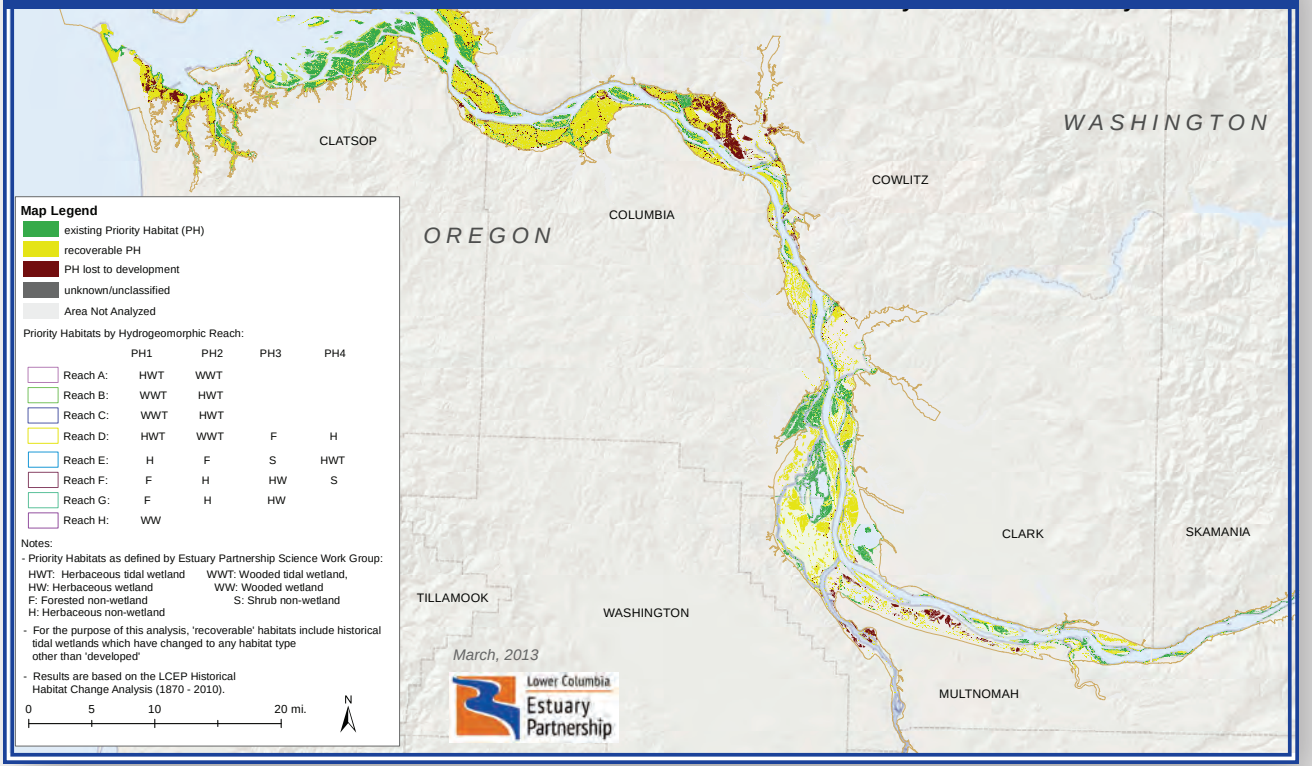
Additional priorities that emerged from our analysis included filling key habitat gaps in migratory corridors (where intact native habitats do not currently exist) and protecting areas of intact native habitat (where they do exist) from the adverse impacts of future development. One effective restoration technique in the estuary has been to reconnect historical floodplain habitats with the mainstem river and its tributaries. Floodplain reconnection increases the amount of habitat available to native species, improves water quality (by filtering pollutants), helps reduce flooding (by increasing storage capacity), and restores the natural food web.

An additional 68,231 acres have been converted to impervious surface, so they will be more expensive to restore to native habitats. Nevertheless, many of these areas are within the Portland-to-Longview corridor, where available native habitat is scarce, so it is even more important that we fill habitat gaps and provide refugia for migratory species in these areas.

Anchor Areas. The Estuary Partnership currently is assessing how much habitat is needed to protect native fish and wildlife species from becoming threatened or endangered, and how to ensure that the lower Columbia has sufficient amounts of resilient native habitat of different types.

Toward this end, we are identifying a series of "anchor areas." These are areas where we can focus protection efforts, so that we have multiple

Lower Columbia River - Extent of Extent of Existing and Potentially Recoverable Priority Habitats



large reserves of priority habitat types (such as tidal emergent wetlands) and can ensure their resilience over time, as conditions in the lower Columbia River change. We also recommend that habitats be restored in multiple areas, to ensure that each habitat is represented in multiple locations in the lower Columbia River.

Conservation Goals for ESA-Listed Species. Another challenge is to determine how much habitat in specific locations is needed in the lower river to recover native species that already are listed under the Endangered Species Act (ESA). To tackle this, we are working with resource managers to set conservation goals, such as abundance targets, that are tailored to each listed species' particular use of lower Columbia habitats. This includes identifying the specific needs of migratory species, such as Pacific salmon and waterfowl that move between habitats as part of their life cycle.

Juvenile Habitat Suitability Index. We completed this index in 2012 with Pacific Northwest National Laboratory (PNNL). The index predicts which mainstem locations will support juvenile salmon and steelhead, based on established water depth, temperature, and velocity threshold values. It also predicts suitable habitats under varying flow conditions.

Bathymetry. The Estuary Partnership completed bathymetric data for 20,000 acres of shallow-water areas that had not been mapped in more than 60 years, if ever. The data fill a critical gap in the Ecosystem Classification, helping to delineate boundaries between aquatic and terrestrial ecosystem complexes. This also is an important element of a lower Columbia terrain model completed by the U.S. Army Corps of Engineers. The terrain model merges bathymetric data with 2010 topographic LiDAR data to generate a single, seamless GIS data set of ground elevations for the lower Columbia floodplain. Having accurate, current elevation data is useful to researchers, managers, restoration practitioners, and engineers and is essential for restoration project design.

Restoration Concept Modeling. In 2012, the Estuary Partnership began using two-dimensional hydrodynamic models to screen potential restoration projects for feasibility. By simulating flow at a site, the models help predict how flow could change as a result of various restoration actions, including levee breaches, channel modifications, and water diversion structure removals. This information quantifies the value or impact of projects in the beginning stages of the restoration process. Having this type of technical assistance will help local partners implement projects that have even a higher likelihood of success.

Ecosystem Monitoring Program. The Estuary Partnership tracks current and long-term trends in habitat, food web, and fish use in the lower Columbia River. In 2012, the Ecosystem Monitoring Program installed the first Land/Ocean Biogeochemical Observatory (LOBO) in the Columbia River

upstream of the Willamette River. The LOBO provides the only continuous measurement of basic water quality conditions between Bonneville Dam and the Willamette River and extends the national Integrated Ocean Observation System in the Pacific Northwest.

Action Effectiveness Monitoring. The Estuary Partnership leads a regional Action Effectiveness Monitoring Program to determine the success of restoration actions on a site, landscape, and ecosystem-wide scale. In collaboration with the U.S. Army Corps of Engineers, Bonneville Power Administration, PNNL, and regional partners, we developed and are implementing "A Programmatic Plan for Action Effectiveness Monitoring in the Lower Columbia River and Estuary." The plan provides guidance to determine the intensity of monitoring necessary for restoration sites, and outlines a framework for managing data in a way that keeps resource managers better informed about the progress of restoration in the lower river and estuary.

Regional Coordination. A key role for the Estuary Partnership is coordinating the numerous partners involved in restoration. This helps invest resources efficiently, identify data gaps, and improves overall regional effectiveness. We regularly convene regional restoration partners, including the States of Oregon and Washington, the federal government, tribal governments, land conservancies, fish recovery boards, watershed councils, and soil and water conservation entities, to ensure that we are working together and making cost-effective investments in our individual programs. National Estuary Programs, including the Estuary Partnership, can integrate and coordinate similar goals among partners, provide scientific and technical information that would be expensive for individual partners, and build a collaborative network—all of which increase efficiencies. NEPs also use ecosystem-based approaches which helps ensure multiple species are addressed.

Why This Matters

Protecting and restoring lower Columbia River habitats is important because estuarine environments are among the most productive on earth, creating more organic matter each year than comparably sized areas of forest, grassland, or agriculture. The sheltered tidal waters of estuaries support unique communities of plants and animals that are especially adapted for life in these transition areas. Thousands of species of birds, mammals, fish, and other wildlife depend on estuarine habitats at some point in their lives. This is true of most commercially important species of fish, including Columbia Basin salmon and steelhead.

In the Columbia River estuary, native fish, wildlife, and plant species evolved over millennia to thrive under historical habitat conditions. Yet large-scale habitat loss has greatly reduced both the amount of historical habitat and the quality of the habitat that remains. Protecting the best of what is left of intact native habitats and restoring degraded areas will be key in protecting and recovering the estuary's native fish and wildlife species.

Challenges Ahead

Climate Change. Climate change has brought changes in precipitation, temperature, and sea level rise that will alter water levels, inundation patterns, and vegetative growth in the estuary. More changes are predicted. In some cases, we may be making investments now to restore sites that eventually will be inundated as a result of sea level rise. Or habitat may be dramatically altered because of changes in precipitation and temperature patterns.

We need to include climate change impacts in our habitat protection and restoration activities now. For example, we can protect cold-water refugia used by migrating salmon and steelhead, map areas that will be inundated or converted by sea level rise, and protect the land behind current wetlands, so that they have room to migrate inland as water elevations rise. We can protect base flow, removing diversions that dewater downstream areas, and plant riparian vegetation to provide shade to streams to protect cold-water refugia for cold-water species; and plant native species that are well adapted to future precipitation and temperature conditions. We need to be flexible, so we can adjust our approach as we learn more about the probable local effects of climate change.

Tracking Habitat Loss. We are not tracking habitat loss. That means we don't know whether the amount of habitat we have protected and restored is more or less than what has been lost since 2010.

Multi-Species Focus. In the past, restoration efforts in the lower Columbia often have focused on providing favorable conditions for a narrow list of species, such as waterfowl, Columbia white-tailed deer, and salmon and steelhead. But these habitat conditions do not necessarily meet the needs of species listed more recently under the ESA. As a result, restoration practitioners and land managers are now "retrofitting" some restoration sites so that conditions there will benefit a broader range of species. Project costs also are increasing, funding and resources for restoration work are limited, and the competition for them is growing. Given these dynamics, it makes sense to proactively shift to a multi-species focus in our restoration activities. A multi-species focus could help us protect common native plant and animal species so they do not become imperiled, keep us from having to "retrofit" restoration sites, and expand our efforts and resources to new types of sites and restoration techniques.

We can expect future restoration projects in the lower Columbia to be more challenging and complex than past efforts, for many reasons: Most of the "easy" projects located on public lands have been completed, there is only so much land available and a limited number of willing landowners, and the cost of acquiring land has gone up.

Targets. The Estuary Partnership is using the habitat change analysis to develop voluntary habitat targets for the lower Columbia River that provide the right amount and types of habitat in the right places to protect common native species.

A next step will add targets for species that use the lower Columbia to aid in recovery of ESA-listed species. Regional partners want to ensure that restoration is using best available science to restore natural processes and functions; the Estuary Partnership's prioritization strategy is an important part of this.

Impact of Toxics. We are not effectively evaluating sites for toxic contaminants. We do not know if restoration sites are contaminated and increasing species' exposure, putting them at risk. To be effective, our restoration activities must be site-specific and take into account the potential impacts of the toxics at each site. Also, although restoring wetland habitats creates a natural filter system that absorbs toxics and protects water quality, wetlands only absorb contaminants. They cannot eliminate them or change species' rate of exposure. This means that wetlands can absorb only so much without damage to habitat and species. We need to take steps to reduce toxic contaminants overall, so that future protection and restoration sites do not become contaminated by the ordinary activities we engage in every day.

Connecting People with the River

Has the Estuary Partnership helped people learn about, experience, and take action to protect the lower Columbia River?

Since 2010, the Estuary Partnership has provided approximately 21,637 students in grades K-12 with over 110,000 hours of science-based classroom instruction, on-river field trips, and environmental service learning opportunities. We engaged 4,500 young people and adults in paddling trips, "paddle and pull" events, and volunteer projects. Many more people experienced the river on their own trips on the Lower Columbia River Water Trail, which the Estuary Partnership has coordinated since 2004.

In the past five years, we retooled several programs to meet teacher and student needs. We increased teacher workshops, doubling what we offered the previous five years; we added our teacher resource kits—a new tool that teachers can use on their own; and we expanded our summer student and community programs. Our student service learning and plantings also dramatically increased: students planted 27,231 native trees and shrubs, compared to 10,910 in the previous five years. Teachers also requested more multi-lesson programs, rather than a one-time one-class lesson.

Volunteers planted two and a half times more trees and removed five times more invasive plants than they did from 2005 to 2010, even with about 2,000 fewer of them. We had an increase in of 38 percent in our on-river trips.

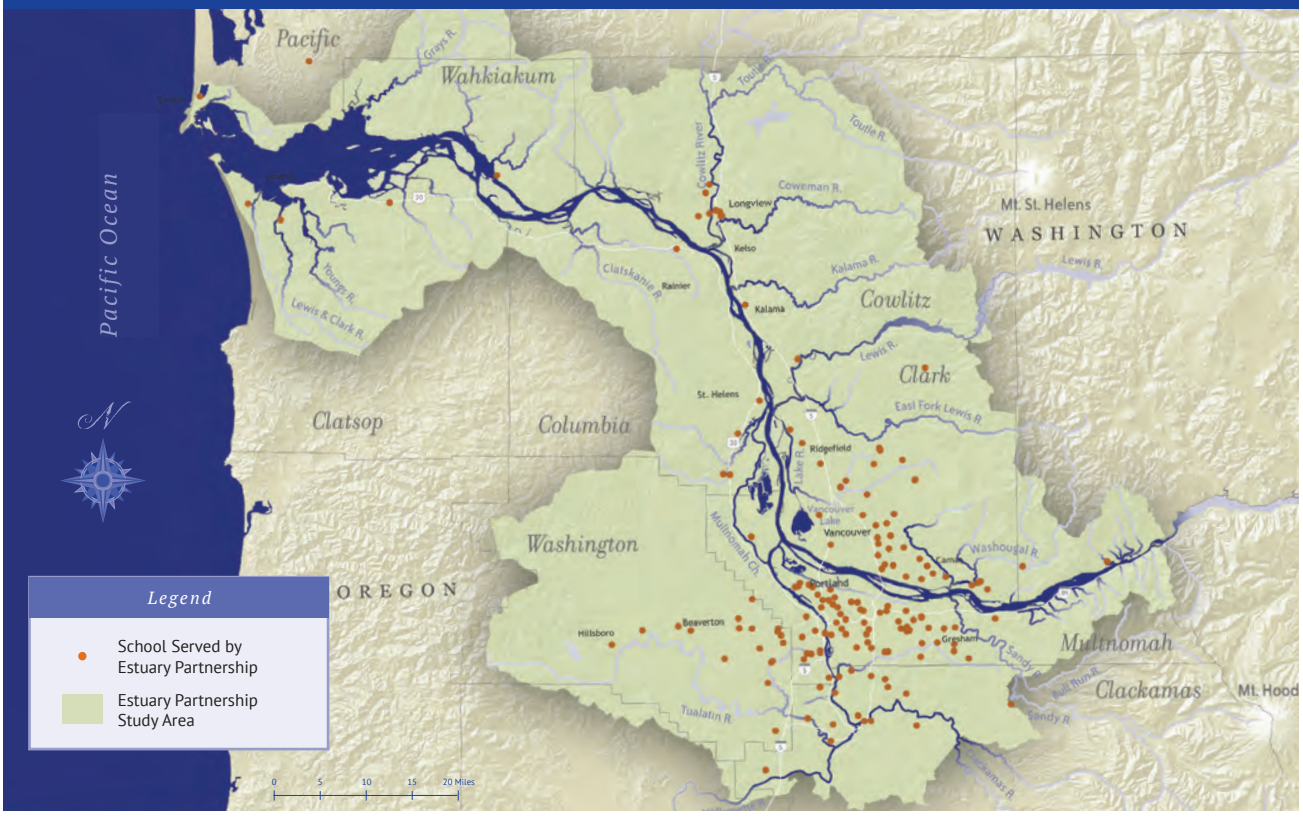
Our education programs are successful, but the need far outstrips what we can provide. Community members need opportunities to connect with nature and engage in outdoor activities, and see how their actions make a difference.

The Estuary Partnership's education and volunteer programs provide opportunities for young people and adults to explore and learn about the lower Columbia River. Each year, thousands of youth and adults participate in these programs, all provided at no cost to students, teachers, parents, or volunteers. Programs are open to all ages and experience levels.

Our **education program** began in 2000 with two objectives: to offer students and teachers meaningful, hands-on learning about local natural resource issues, and to help teachers integrate watershed education into the science curriculum to help meet state standards. We now design programs to also meet Common Core and Next Generation Science Standards. For students, our education program provides science-based classroom instruction, service learning opportunities, and on-river field trips. For teachers, it provides access to environmental education, trainings and workshops, as well as resource kits that have natural artifacts and scientific and teaching tools and resources. These additional resources help teachers incorporate outdoor education into their curriculum on their own. Each year, we receive more program requests than we can accommodate.

Through our **volunteer program**, community members take part in riparian enhancement projects at state parks, wildlife refuges, and other public areas along the lower Columbia River. We also organize paddling trips for people of all ages to get on the river, using our 29-foot "big canoes," a first for many.

Estuary Partnership Education Project Sites 2000–2014



What is being done?

Science-based Classroom Lessons and Outdoor Field Trips for Students. Our education program combines academic classroom lessons with meaningful, hands-on watershed experiences. The Estuary Partnership's professional environmental educators teach complex science concepts to students in the classroom, in the field, and on the water. They work closely with teachers to identify individual classroom goals, incorporate watershed science into lesson plans, and lead outdoor activities that reinforce the new concepts. Each student receives an average of five hours of instruction in the classroom and in the field.

In the **classroom**, Estuary Partnership educators deliver a series of up to four 1-hour, in-depth lessons on various watershed ecology topics. This instruction prepares students for their outdoor experience and increases their understanding of science concepts. Classroom lessons are hands-on and encourage student inquiry, critical thinking, and observation. Field trips then build on the classroom lessons. Typically students go to a natural area close by to minimize transportation time and costs, make the field experience more meaningful, and increase the likelihood that students will return to the site on their own or with their parents. On field trips, students usually spend four hours doing on-the-ground activities such as planting native trees and shrubs, exploring the watershed, testing water quality, or sampling macroinvertebrates.

For **service learning,** the Estuary Partnership works with teachers to design and implement a project at a local natural area. Students have a chance to enhance their local watershed by applying what they learned in class and getting their hands dirty. For example, students might learn about plant identification and the dynamics between native and invasive species and then, out in the real world, remove invasive vegetation or plant native trees and shrubs. We organize and lead all service learning activities and provide all tools, equipment, and supplies.

During **on-river trips**, students use their scientific observation skills to explore the local natural area as they paddle in our stable, 29-foot canoes. Each canoe holds up to 12-14 people plus two Estuary

Partnership educators, allowing us to accommodate an entire classroom of students. Lessons come to life as students experience and discuss what they learned in the classroom. They paddle, learn about water safety, and practice teamwork while enjoying the river. For many, this is their first trip ever on-water. They have the chance to watch osprey fishing, spot river otters, feel the river current or ocean tides, and enjoy other unique experiences. Since purchasing our big canoes in 2007, we have taken 14,296 students on the river. The boats are conducive to teaching groups of people, can be easily transported, and are extremely safe.

Schoolyard Stormwater Project. During the past five years, the Estuary Partnership completed a schoolyard stormwater project at Hosford Middle School in Portland, Oregon, our fifth. The project combined environmental education with construction of a swale on school grounds to reduce stormwater runoff to the city's combined sewer system. Students helped plant more than 300 native shrubs, sedges, rushes, and groundcovers. The finished swale infiltrates about 105,000 gallons of runoff per year, from 4,666 square feet of roof area. The swale also improves the school grounds and provides ongoing opportunities for hands-on science studies and stormwater education. Nearly 100 students, in three classrooms, worked with us during the project, and it remains as an outdoor classroom for future students.

Resources, Trainings, and Workshops for Teachers. Since 2010, the Estuary Partnership provided direct programs, resources or training to more than 1,030 teachers throughout our study area. These teachers specifically note their lack of expertise in teaching science outdoors, along with obstacles in funding fieldwork and a perception that outdoor science experiences are at odds with learning objectives such as Common Core State Standards. By participating in our education program, teachers observe Estuary Partnership educators in action and gain skills and ideas for leading their own outdoor programs. We help integrate science and nature with activities that strengthen reading, writing, and math skills and promote access to environmental education.

Between 2010 and 2015, the Estuary Partnership conducted 11 professional development teacher workshops, involving nearly 220 teachers. These workshops expand teachers' knowledge of environmental concepts, teach

hands-on classroom and field activities, and give teachers the tools and skills they need to work with students on their schoolyard or local natural area. We are developing two additional teacher workshops that will help teachers integrate outdoor science education with Common Core literacy requirements.

The Estuary Partnership also developed nine teacher resource kits in response to the many teacher requests for our education program that go unmet because of our already full schedule. These kits help build capacity and provide resources for teachers to lead outdoor science education themselves, such as lesson plans, binoculars, field guides, and unusual natural artifacts. Eight resource kits are available—Animal Signs and Observation, Animal Tracks, Bird Beak Adaptations, Explore Birds, Food Web, Macroinvertebrate Sampling, Native and Invasive Plants, and Water Quality Sampling—and three more are in development.

Volunteer Events for Community Members. Throughout winter and early spring, the Estuary Partnership organizes weekend volunteer projects to engage the community in riparian habitat enhancement. Volunteers help remove invasive plants such as Armenian blackberry and English ivy, and they plant native trees and shrubs. Most sites are along streams that are impaired for temperature, so they need more shade and native vegetation. Sites include Meldrum Bar Park, the Sandy River Delta, Benson State Park, Mirror Lake, Ross Island, Sand Island, Lawton Creek, Salmon Creek, Ridgefield National Wildlife Refuge, and Steigerwald Lake National Wildlife Refuge.

Since 2010, our volunteers have removed 27 truckloads of invasive vegetation and planted 19,549 native trees and shrubs. Combined with our student projects, that is more than 46,000 native trees and shrubs planted along riparian corridors that help lower water temperature and create habitat.

Over the last few years, we have integrated our student and volunteer programs with large restoration projects when it is safe to do so. At La Center Bottoms in Washington, we are restoring 32 acres along the East Fork Lewis River and Breeze Creek; students and volunteers will plant two of those acres along Breeze Creek as part of service learning projects and weekend volunteer events. This has an added benefit of exposing students to a variety of career options and to see the range of people and expertise involved in habitat restoration.

Community Paddles. The Estuary Partnership provides community paddling trips from spring through early fall in our two 14-passenger, 29-foot canoes. With their exceptional stability and comfortable design, the canoes soothe the nerves of young or first-time paddlers, allowing them to gain confidence and thoroughly experience their surroundings. Our educators start by reviewing safety procedures to ensure a safe trip and to help empower youth and adults to have a safe, positive, on-water experience, and one that makes them want to come back.

Our program engages people with their physical place and opens them up to the valuable recreational opportunities of nearby rivers and lakes. In Washington, we lead paddles along Lacamas Lake in Camas, Lake River in Ridgefield, and Black Lake in Ilwaco. Oregon paddling areas include the Willamette River near Portland, Tualatin River, Multnomah Channel near Sauvie Island, sites along the lower Columbia River, Scappoose Bay, and Coffenbury Lake at Fort Stevens State Park. The big canoes provide a unique venue for people to learn natural history, discuss issues affecting the watershed, observe wildlife, and experience the watershed firsthand.

Paddle and Pull Events. Each summer the Estuary Partnership offers a few "Paddle and Pull" events that combine removing invasive plants or planting native trees and shrubs with an on-water experience in our big canoes. Volunteers paddle to an island site, such as Ross Island on the Willamette River or Sand Island on the Columbia River, to take part in a habitat enhancement project to eradicate invasive plant species.

Lower Columbia River Water Trail. The Estuary Partnership coordinates and manages the Lower Columbia River Water Trail. The Estuary Partnership provides overall trail management, promotes the trail, and coordinates with partners on enhancements. On the trail website, boaters can find a safety guide and a searchable map showing the locations of launch and landing sites, camping areas and hotels, on-water restaurants and grocery stores, and points of interest.

From 2010 to 2015 we:

- Improved the trail website, better integrating the site with the Estuary Partnership's website. We are updating the mapping functions and layout.
- Developed new trip recommendations that have videos and photos, so paddlers know where to go and what their experience might be like.
- Engaged more than 30 partners in a workshop to determine the need for, size, elements, and design of water trail signs.
- Secured funding from the National Park Service to work with site owners on signage. We then coordinated the development and production of more than 60 site-specific signs and started delivering them to site owners for installation.
- Initiated an agreement with the Oregon Department of State Lands to cooperate on state-owned water trail island campsites.

We also are contributing our expertise to the development of the Lewis River-Vancouver Lake Water Trail by assisting with coordination and website mapping. We are doing this as part of our work on Vancouver Lake. We also received funding from REI to help improve access for non-motorized boaters at the Ridgefield Boat Ramp.

Why This Matters

Our educational challenges are real: Teachers often have to cut back on science lessons in K-5 to focus on math and reading. Many K-5 teachers do not have the training to teach applied outdoor science or do not have the materials. Schools provide fewer and fewer opportunities to learn outdoors and youth are less connected to natural areas. Bringing students' science lessons to life and getting them outside to learn firsthand is a critical factor in raising academic success and gaining skills to meet our environmental challenges. With Oregon and Washington graduation rates below the national average, and marked disparity among student learning for low-income students, we need to give students ways to succeed that incorporate how they learn best.

We know from a growing body of research that experiences in nature enhance academic achievement, and that students are more motivated to learn when content is connected to their place. Nature experiences expand students' learning, stirs curiosity and imagination, and strengthens math and reading proficiency. Students develop critical thinking, problem solving, and decision-making skills, along with the ability to both act and reflect. They better understand science concepts, the importance of biodiversity, and the unique role that humans play in the ecosystem. It helps teachers meet benchmark requirements, and helps keep students on track to graduate.

For many students, our field program is their first experience on the water or at a local natural area. The outdoor setting provides learning opportunities that are not available in the classroom and supports students who learn better through direct experience. Research is clear that we retain six times more of what we experience than what we read or hear. Most important, field trips connect students to the world right outside their door.

Hands-on volunteer and recreational activities that we organize for community members engages them in caring for the lower Columbia River, and helps them connect the impact of their actions to its health and theirs. It also helps them feel vested in their local community and natural areas.

Accessing the river can be challenging, especially for non-motorized craft. It's a big river, a big channel that carries a lot of river traffic. There is a growing popularity for non-motorized boating. The Lower Columbia River Water Trail helps fill a need and provides information about how to paddle, along with safety information. It also supports and promotes paddling shops, grocery stores, lodging, on-water restaurants, and other amenities that bring paddlers to local communities.

Challenges Ahead

Diversity and Low-Income Students. We focus on underserved student populations by prioritizing schools with a high percentage of students receiving free or reduced-priced lunches. Yet, there are many more students from diverse cultures and socio-economic backgrounds that lack opportunities for outdoor learning and access to natural areas. Determining the unique educational needs of the diversity of students in our study area is challenging, but it is something we are addressing.

Teacher Resources. Schools provide fewer and fewer, if any, opportunities for students to learn outdoors. Teachers often do not have the resources or training to teach in outdoor settings, or to connect such learning to state education standards.

Estuary Partnership Funding. We have diversified our funding sources for our education and volunteer programs. They now are funded through the support of more than 50 corporate sponsors, several private foundations, and multiple public entities. This support demonstrates our ability to develop and sustain programs. But it doesn't meet the need. Each year we are fully booked by January, and have a waiting list. Competition for grant funds and corporate support increases every year. If we had the resources, we could provide on-river educational trips on our 29-foot canoes every day between April 1 and November 1.

Student Science Need. The approximately 4,500 students we work with each year represent less than 2 percent of the student population in our study area. Demand for science-based, outdoor-focused educational programming outpaces our ability to provide it. With a focus on math and reading, we are developing our programs to link science lessons to math and reading proficiency.

Access to the River. Non-motorized boating and the Lower Columbia River Water Trail are growing in popularity. We need to identify a funding source to add a water trail coordinator to expand use of the trail, improve it, and increase the public's access to the river. But, finding that funding source and sustaining it are challenging.

Land Use

Do our land use decisions protect water quality?

A key indicator of how land uses affect water quality is how we manage stormwater. Since 2010, many people in the region—from individuals to builders to government agencies—have expanded and accelerated the use of innovative approaches to stormwater management—approaches that are designed to lessen the impacts of urban land uses on water quality, habitat, and fish and wildlife. Especially in our cities, using "green" infrastructure, which allows stormwater to infiltrate on-site, has gone from being a novel idea to being a visible, acceptable, and desirable reality. In many cases features such as ecoroofs, permeable pavers, and infiltration swales are able to manage stormwater on-site, with no runoff at all.

Data show the wisdom in this approach: we are learning much more about the harmful effects of toxic contaminants conveyed by stormwater and the value of on-site infiltration in protecting water quality.

Low-impact development and on-site stormwater management have both environmental and economic benefits, but they still are far from the norm. This is especially true for existing infrastructure, which can be difficult, expensive, and time-consuming to retrofit.

There is no easy measure or inexpensive way to directly assess if our land use decisions are protecting water quality, especially across large areas like the 4,300-acre lower Columbia River watershed.

Today, although there still are wetlands and forests within the lower Columbia River area, our land and land uses are fundamentally different than they were historically. This is particularly so in urban areas, where roads, parking lots, buildings, warehouses, shopping centers, houses, sidewalks, parks, and a host of other developments with impervious surfaces have reshaped the landscape.

What is on the land and the various types of land uses (forest, farms, urban areas, etc.) have a direct impact on the lower Columbia River's water quality, habitats, and species. When land surfaces are covered by buildings, roads, and parking lots, those surfaces prevent rainwater infiltration into the ground, changing stream flow, and contributing toxics to the environment. For example, oil and grease from cars and trucks, pesticides and fertilizers from lawns and gardens, bacteria from pet waste, excess sediment from forestry operations, heavy metals from rooftops and parking lots, mercury from air deposition, copper from vehicle brake pads—all make their way to rivers and streams as stormwater runs off the hard impervious surfaces that are common in our urban landscape.

As the amount of impervious surfaces increase, so does the amount of runoff, and stream health declines. More people mean more homes, shopping areas, businesses, roadways, and parking areas. It adds up. The degradation becomes acute when the ratio of impervious surfaces in a watershed exceeds 25 percent. Instead of soaking in, rainwater stays on the surface and rapidly runs off in unnaturally large amounts, picking up pollutants along the way. During periods of high rainfall this concentrated flow causes flooding and erosion, sometimes damaging streamside vegetation and aquatic habitat. It also decreases stream flows during dry periods because there is less groundwater available to recharge base flows.

Development isn't bad. It is a matter of how we develop, and where, so that we can protect the region's water quality, habitat, and species even as our urban population grows.

What is being done?

Tracking Impervious Surfaces. The acreage of impervious surfaces in the lower Columbia River area is growing. NOAA completed a land cover analysis that shows that, between 2001 and 2010, the amount of land in the region that was covered by impervious surfaces increased by approximately 2.5 percent, while the amount of forested land dropped by almost 8 percent.

In 2011, the Estuary Partnership completed a land cover analysis of the Lower Columbia River floodplain using high-resolution aerial imagery and innovative image processing techniques. Field observations of various cover types helped ground-truth the data. Key features we analyzed include estuarine and tidal freshwater wetland types, impervious surface, forest cover, agriculture, and bare substrate.

The land cover data fill a critical gap in the Columbia River Estuarine Ecosystem Classification and enable land users and managers to make more informed decisions about land use, restoration, and development.

The information also provides a snapshot of current conditions. This can serve as a baseline against which we can measure changes in the landscape over time.

Green and Low-Impact Development. Increasingly, cities and states are encouraging or even requiring land use and building practices that incorporate "green" infrastructure in order to protect water quality. Components include things like large trees that capture and evapotranspirate rain; infiltration basins, grassy swales, and permeable pavers, whose porous surfaces allow rainwater to infiltrate into the ground; ecoroofs, which capture and infiltrate rain; and cisterns that store stormwater so that it can be reused later to flush toilets or irrigate lawns and gardens.

In its 2014 Stormwater Management Manual (first adopted in 1999), the City of Portland explicitly states a goal of using vegetated surfaces to treat and infiltrate stormwater on-site. Benefits include reductions in pollution, peak stream flows, and overall stream volume, as well as improvements in groundwater recharge – benefits that will play a critical role in improving watershed health.

Similarly, the 2012 Washington Department of Ecology Stormwater Management Manual for Western Washington outlined new measures to control the quality and quantity of stormwater from both new development and redevelopment. Cities across western Washington have adapted their stormwater management policies in order to comply. Some changes represent fundamental shifts in municipal stormwater management that will reduce the future impacts of impervious surfaces and stormwater runoff on water quality, species, and habitats.

Schoolyard Stormwater Projects. In 2013, the Estuary Partnership finished a series of five school-based stormwater projects that combined stormwater-focused education with construction of stormwater facilities on school grounds. On the last project, at Hosford Middle School in southeast Portland, students helped build a stormwater infiltration swale that collects and infiltrates approximately 105,000 gallons of runoff per year, from 4,666 square feet of roof area.

Why This Matters

In 1995, when the Estuary Partnership began, the population of the Portland, Oregon – Vancouver, Washington metro area was 1.5 million. Twenty years later, it is 2.3 million. In the next twenty years, it is projected to be about 3 million. More people bring more building, roads, etc. and with that the potential for more stormwater runoff.

With the increases in the amount of impervious surfaces and decrease in forested land, stormwater runoff from urbanized areas remains one of the biggest challenges facing the lower Columbia River and its tributaries.

Stormwater runoff degrades water quality. Because stormwater usually is relatively warm, it loads its receiving streams with "thermal pollution." It also transports toxic contaminants from impervious surfaces directly to storm drains, creeks, and small streams—and eventually to the lower Columbia River.

Researchers from the Washington Stormwater Center (affiliated with Washington State University) are demonstrating just how toxic stormwater can be to aquatic life. In one study, the research team collected stormwater runoff from a Seattle-area highway. The team filtered half of the stormwater through soil columns that mimic what happens to stormwater in a rain garden. The other half was left unfiltered. The samples were put into different aquariums, and 10

juvenile Coho salmon were added to each one. Researchers had expected to monitor the fish for four days, but within four hours all of the salmon in the aquarium with the unfiltered highway runoff had died.

In our region, urban areas are contributing significant amounts of toxic contaminants to the lower Columbia River, presumably in large part through stormwater runoff. Toxic contaminants impair the normal function of the nervous, immune, endocrine, and reproductive systems of fish and wildlife and affect their survival and reproductive success.

Challenges Ahead

Measuring Land Use Impacts. Measuring how land use decisions protect water quality across a large geography is difficult. Continued improvements in satellite technology will make it easier to better measure impervious surfaces, which is a good surrogate measurement tool – since as impervious surface percentages within a watershed go up, water quality generally declines.

Standardizing On-Site Stormwater Practices. Local and state governments, developers, builders, and homeowners can make a huge impact by employing on-site stormwater management as a standard practice. Without on-site management, stormwater impacts will increase as the amount of impervious surfaces and our cities grow. Though development projects that integrate on-site stormwater management have become more common, they are not yet the norm. Incentives and regulations can encourage, or require, adequate on-site stormwater management.

Understanding Stormwater Impacts. The diverse and diffuse nature of stormwater (which comes from tens of thousands of different sites) makes it everyone's problem. On an individual level, our houses, driveways, roofs, cars, and our behaviors associated with those things all have an impact on stormwater and water quality. The impacts of one individual's behavior is small – but the cumulative impact of hundreds of thousands of people's individual actions is huge. When we collectively choose to use fewer fertilizers and pesticides, pick up pet waste, drive less, fix car leaks, and disconnect downspouts, it will make a difference.

Funding. For the Estuary Partnership, we learned a lot from our schoolyard stormwater projects. An ongoing challenge for us is finding funding dedicated to helping not just schools but local governments and other entities accomplish stormwater management projects.

Short and Long-Term Economics. Integrating on-site stormwater infiltration practices into the design and construction of new developments often is more economical in both the short and long term than conventional stormwater practices. Retrofitting older buildings, roads and other infrastructure to integrate stormwater infiltration can be initially difficult and expensive. To reduce the impacts of stormwater on water quality and species though, we are going to need to take a longer term view that more holistically incorporates the costs of not taking action. While the initial costs might be high, it can mean less long-term maintenance, fewer impacts to water quality, species, and human health, and reduced future clean-up costs.

Endangered Species

Are threatened and endangered species in the lower Columbia River recovering?

The number of threatened or endangered species in the lower Columbia River has gone up since 2004. Today, 40 species of plants, fish, and wildlife that live in or use the lower river are listed as threatened or endangered under the Endangered Species Act. This is up from 32 species in 2010 and 24 species in 2004. There also are many more candidate species and species of concern, including most species of bats and amphibians. More species are likely to be listed.

Over the last decade, salmon and steelhead received a great deal of focus. Federal and state agencies and many conservation partners are working on several large-scale programs to benefit salmon and steelhead and are investing significant resources in their recovery. Less is known about how amphibians, bats, and insects are faring. In general, we are not adequately tracking these and other species populations.

In the past five years, significant investments have been made to recover Columbian White-tailed deer, bald eagles, and other fish, mammals, and birds, and these efforts are making progress. The Estuary Partnership mapped areas within the deer's historical range to help with the relocation of deer populations to other suitable habitat. We also focused our restoration efforts on habitat for salmon and steelhead.

Multiple factors affect recovery and listing of species: our approach to protecting and restoring habitat in the lower Columbia has not been keeping up with new species listings; invasive species are taking over native habitats, and toxics have significant lethal and sublethal impacts.

Many of the listed species found in the lower Columbia use its habitats temporarily for migration, rearing, over-wintering or nesting at specific times during their life cycles.

Restoring habitat in the lower river is essential for their recovery. Other listed species have habitat ranges that extend beyond the lower Columbia. For these, restoration work in the lower Columbia needs to connect with broader restoration to recover the species. Past efforts at protecting species won't meet the challenges ahead.

What is being done?

For this report, we focus on three species, salmon and steelhead, Columbian White-tailed deer, and bald eagles.

Salmon and Steelhead. Today, fewer than 1 million wild salmon and steelhead migrate up the Columbia River system each year to spawn - that's down from an estimated 8 to 16 million historically. Thirteen species of salmon and steelhead now are listed as threatened or endangered under the federal Endangered Species Act.

ESA-listed salmon and steelhead continue to face serious threats in the lower Columbia. More than half—over 114,000 acres—of the native habitat that existed in 1870 is now gone, converted to agriculture, industrial uses, or urban and suburban development. Only 45 percent of the forested uplands that used to exist along the lower Columbia River remain, and only 30 percent of the river's vegetated tidal wetlands—a crucial habitat for salmon and steelhead. These habitat losses are significant for listed salmon and steelhead. In addition, changes in river flow have made it more difficult for juvenile salmon to access the floodplain habitats they need to rear and have decreased the amount of organic matter (that salmon prey feed on) exported to the mainstem to drop. Toxic contaminants in water, sediment, and prey continue to affect the survival and productivity of salmon and steelhead using the lower Columbia. In addition, the widespread introduction of invasive species, and the increase in predators such as sea lions and double-crested cormorants threatens salmon populations.

These threats are being exacerbated by the effects of climate change: Water is getting warmer, and precipitation patterns are changing. Higher sea levels are introducing acidification and low dissolved oxygen levels to the estuary through tidal exchange. The impacts jeopardize the already limited quantity and quality of habitats in the lower river.

We have made a lot of progress in protecting and restoring habitats that are important for salmon and steelhead. Since 2000, more than 100 partners have protected or restored 21,399 acres of habitat in the lower Columbia River. They have acquired land, placed large wood in streams, planted native species in riparian areas, and breached levees and replaced culverts so that fish can access and use historical habitats. Still, much work remains to be done if we are to recover wild salmon and steelhead populations and protect all species.

Why This Matters

All salmon and steelhead in the Columbia River Basin use the lower Columbia. The lower river and estuary is a critical migration corridor for steelhead, sockeye, Chinook, chum, and coho. Fall Chinook make extensive use of the floodplain and shallow-water habitats in the lower river for rearing, as do chum and coho, to a lesser degree. Steelhead and sockeye also use these habitats, although in smaller numbers. Steelhead and sockeye largely benefit from lower river habitats indirectly, such as when vegetative detritus makes its way from floodplain habitats into the mainstem, where it contributes to the food web.

Columbian White-tailed Deer. Recovery of Columbian White-tailed deer has advanced in the past five years. In 1967, Columbian White-tailed deer were listed as endangered. Recovering the Columbian White-tailed deer requires achieving a secure, sustainable population over a wide geographical range, protecting the deer from severe weather events, conserving remaining suitable habitats, and restoring other areas to create new habitat.

In 2013, the U.S. Fish and Wildlife Service (USFWS) recommended that the species be down-listed from endangered to threatened. Currently in the lower Columbia River region, there are just under 1,000 deer, about 2/3 of them living on private land. The USFWS's recovery plan, which was developed in 1983, recommends that there be 400 individuals, in three viable subpopulations occupying secure habitat, before the species is considered recovered. Currently, three subpopulations—Julia Butler Hanson National Wildlife Refuge Mainland, Tennasillahe Island, and Puget Island—meet the definition of being viable (50 individuals or more) and secure (free from human disturbance and safe from natural perturbations). Although this meets the minimum criteria, the USFWS chose to downlist rather than delist the deer because of recent threats to some unsecure areas, such as changes in land ownership.

Full recovery is within sight. In 2013, the USFWS trans-located 37 deer from the Julia Butler Hansen National Wildlife Refuge to the Ridgefield National Wildlife Refuge, to protect them from a failing levee. The next year a new levee was constructed at the Julia Butler Hansen Refuge to reduce risk to the deer from flooding, and the USFWS continued trans-locating deer in an effort to establish a fourth secure subpopulation at the Ridgefield Refuge. The Julia Butler Hanson Mainland population has returned to about 100 deer, and the Ridgefield Refuge population appears to be thriving. If the subpopulation at Ridgefield can be maintained at more than 50 individuals, the deer could be delisted.

With funding from Bonneville Power Administration, in 2013 the Estuary Partnership and USFWS mapped areas within the deer's historical range that are suitable for the species. Many of the mapped areas are on private lands. To maintain the health of the population, it will be vital to expand efforts to protect habitat on these privately owned lands. Toward that end, partners such as the Natural Resources Conservation Service are providing critical funding to private landowners so they can apply best management practices that will improve habitat quality for Columbian White-tailed deer.

Why this matters

Over time, the range of the Columbian White-tailed deer dropped from 13 million acres in western Oregon and Washington to just 350,000 acres today. With such a small range and small population numbers, Columbian White-tailed deer in the lower Columbia River region are vulnerable to extinction from prolonged severe weather, excessive predation, loss of habitat, and the spread of disease. Among other things, additional habitat is needed, and existing habitat must be protected.

Bald Eagles. Bald eagles are one of the great success stories of the Endangered Species Act. Populations of bald eagles in the Pacific Northwest have increased greatly since the 1970s, when DDT and other organochlorine compounds were banned. After decades of efforts to restore bald eagle habitat and reduce threats to its survival, the bird was delisted in 2007.

Yet our work is not done. Recent studies have shown lower levels of DDT and organochlorines in eagle populations in general. But other studies are finding these contaminants in sediments in the lowest sections of the lower Columbia, where they can get into the food chain and bioaccumulate, eventually concentrating in top predators such as bald eagles.

Why This Matters

DDT and other organochlorine compounds change bald eagles' parenting behavior during incubation and cause eggshells to thin, so that the eagle chicks end up dying before they hatch. Organochlorine compounds in water and sediment accumulate in the fatty tissues of organisms living in the river. Over time, organochlorine compounds bioaccumulate in the tissues of fish and birds as they eat prey from

the river. The process increases mortality and disease susceptibility, impairs reproductive organs and thins eggshells, and causes significant problems for predators at the top of the food chain.

Challenges Ahead

Avoid Listing. The number of ESA-listed species in the lower Columbia region continues to grow: from 24 in 2004 to 32 in 2010 and now 40 in 2015. Many more species are being evaluated for future listing. To change this trajectory of species imperilment, we must protect and restore native habitats, improve public and private land management practices, reduce exposure to toxic contaminants, and address more species-specific threats, such as disease. Proactively protecting species so that they do not become imperiled in the first place is less costly, a much better use of finite dollars, and more effective for species' overall survivability than trying to recover them after they become threatened or endangered.

Set Targets. Native species continue to become imperiled, despite our restoration and protection actions over the last 15 years. Past efforts and methods are not enough and we are now rethinking our approach. The Estuary Partnership is developing voluntary habitat targets for the lower Columbia River that will help us provide the right amount and types of habitat in the right places to protect common native species. A next step will add targets for species that use the lower Columbia that will aid in recovery of ESA-listed species.

Toxics. Exposure to toxic contaminants can have lethal and sublethal effects on fish and wildlife species. Sublethal effects are important for the long term success of a species population because they include changes in physiology that make individual fish or animals more susceptible to disease, changes in behavior that make them more susceptible to predation and changes in reproduction that lowers reproductive success or causes them to pass genetic mutations on to offspring. Amphibians are highly sensitive to environmental pollutants because of their porous skins. The status of amphibian populations is an excellent indicator of how an ecosystem is functioning as a whole in part because of how sensitive they are to environmental pollutants. Worldwide, almost half of all amphibian species are in decline.

Species to Watch: Bats

There are nine species of bats found in western Oregon and Washington. The little brown bat was once North America's most common bat but now is being considered for ESA protection. If it ends up getting listed, it would be joining 40 percent of all of the nation's bat species.

Why are bats at risk? Like many animal species, bats have lost much of their historical habitat through urban, industrial, and agricultural development. Many of them have adapted to using attics because these spaces provide stable temperatures, protect bats from predators, and serve as replacement roosts.

Bats survive over winter by hibernating in cavities like trees, caves, mine shafts, and attics; or migrating to regions where insects are available. In late September or October bats enter hibernation sites protected from disturbances such as predators, light and noise. Hibernation sites need sustained cool temperatures and high humidity to help bats maintain low body temperatures and keep them from dehydrating. A hibernating bat needs to survive five to six months of winter on only a few grams of stored fat. If a bat is awakened or disturbed, it loses vital energy reserves and may not survive until spring.

A significant new threat to bats is white-nose syndrome, a fungal disease transmitted primarily from bat to bat. Since it arrived from Eurasia in 2006, it has killed more than six million bats; as of 2015, the syndrome has been found in 25 U.S. states and five Canadian provinces. The fungus invades the skin of hibernating bats and disrupts their hibernation cycle, so that they wake

repeatedly during the winter. This burns up their limited fat reserves. Dehydrated and hungry, affected bats often leave their hibernation sites too soon—in late winter—to search for food. With no insects available at that time, they die. Mortality in some hibernation sites is as high as 90 to 100 percent.

Most species of bats that live near the lower Columbia River are susceptible to white-nose syndrome. The fungus is not yet present in the Pacific Northwest, but fish and wildlife managers think it's just a matter of time before the fungus spreads to this area. To help prevent it from spreading, people in Oregon and Washington who visit federal parks and cave sites frequented by bats are asked to decontaminate their shoes and clothing before entering if they have been in other sites frequented by bats.

Why This Matters

Bats are a vital part of the lower Columbia River ecosystem. As predators of night-flying insects, including mosquitoes, bats provide crucial natural pest control. An adult bat eats about 1,000 insects every hour, and a single bat can consume as much as its body weight in insects each night. The consequences of a widespread bat die-off could include population explosions of pest insects that plague agricultural crops. Increased insect infestation could increase farmers' costs by billions of dollars annually.

Species to Watch: Amphibians

Worldwide, amphibians are in trouble. Nearly half of the world's newt, salamander, frog, and toad populations are in decline. Almost one-third of amphibian species are threatened, at least 168 of them already have gone extinct.

The typical amphibian life cycle consists of an aquatic larval stage lasting a few months, followed by a brief metamorphic period, and then several years living on land, foraging under leaf litter and downed logs and amongst vegetation. Typically, adult amphibians return to water to mate and lay eggs. Larval stages often eat aquatic algae, providing a natural means of moderating plankton blooms. Adult amphibians, similar to juvenile salmon and bats, are important predators of invertebrates, and are prey for larger organisms.

The list of threats to amphibians is familiar: habitat loss, pollution, infectious disease, invasive species, and climate change, plus over-harvesting for the pet and food trades. Climate change and an emerging disease, called chytridiomycosis, are thought to be the biggest threats to amphibians today.

Chytridiomycosis is a deadly skin disease that has been detected in amphibian populations in Oregon and Washington and poses a risk to the 18 native species of amphibians that use the lower Columbia River. Chytridiomycosis is caused by a fungal chytrid pathogen detected in 36 countries and believed responsible for the extinction of more than 100 amphibian species around the world.

Amphibians generally have thin, porous skins that can easily absorb water and electrolytes. But infection with the chytrid fungus causes the skin to thicken, or even slough off completely. This is a problem because an amphibian's skin is one of its most important organs, involved in respiration, hydration, osmoregulation, and thermoregulation. This can lead to anorexia, reduction in electrolyte levels, lethargy, behavioral changes, and death, depending on the infection's intensity. The disease is largely spread through the pet trade and, less commonly, through amphibian movement between sites. Native amphibian populations generally have no natural defenses against the disease, so when it spreads to a new location, it frequently leads to localized decline or extinction.

Toxic contaminants are another cause of amphibian declines. Amphibians are highly sensitive to environmental pollutants. Exposure to contaminants can lead to developmental and behavioral abnormalities, increase susceptibility to predation, and decrease reproductive success. Toxic contaminants also weaken the amphibian immune system, making the animals more susceptible to parasites, disease, and ultraviolet radiation. In addition, certain pesticides can disrupt the endocrine system, resulting in sexual deformities such as hermaphroditism (i.e., having both male and female reproductive organs).

Why This Matters

Amphibians are an often overlooked but important component of the lower Columbia River ecosystem. Because amphibians live in both aquatic and terrestrial habitats at different points in their lifecycles (i.e., in the water as eggs, larvae, and tadpoles, then on land as adults), they are key components of both these food webs. Declines in amphibian populations can result in drastic increases in insect populations.

Climate Change

"The effects of sea level rise, increasing severity of storms, and increased erosion and flooding pose threats to habitat and local infrastructure."

The data and the evidence are pretty clear: we are now living with a changed climate. The variability in our climate is different from the patterns documented in our geologic history; we are experiencing more rapid and more intense changes. The changes affect nearly all of what the Estuary Partnership does.

The Columbia River is a snowmelt driven river system, except for west of the Cascade Mountain Range, where it is largely rain driven. Changes to the timing and quantity of streamflows, resulting from changes to snowmelt and more precipitation falling as rain, already have been observed and will continue. These have far-reaching consequences such as reducing access to tributary and floodplain habitats for aquatic species, already reduced because of water diversions and widespread diking.

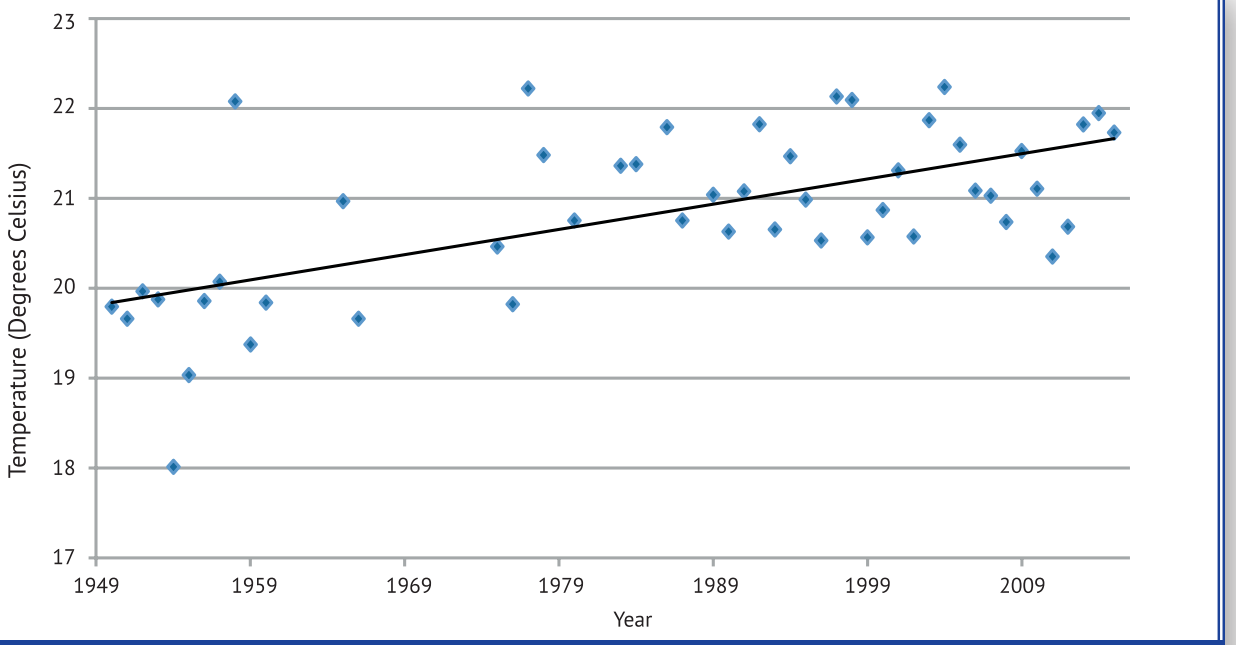
The effects of sea level rise, increasing severity of storms, and increased erosion and flooding pose threats to habitat and local infrastructure. Rising sea levels also bring ocean acidification and low oxygen conditions into our estuaries through tidal exchange. Changing precipitation timing and amounts have created drought stress in our trees, making them more susceptible to disease, insect outbreaks and wildfires; combined with increases in large wildfires, we are now starting to see widespread transformations of our forests.

How climate change is affecting specific processes, vegetation, habitats, and fish and wildlife species in the lower Columbia River and estuary is something we don't fully know. We have much better information about global and even regional climate projections and their impacts. We need to understand the specific impacts to the lower Columbia River and estuary.

So far, there has been no site-specific assessment of predicted sea level rise in the lower Columbia, so we don't know which areas are susceptible to submersion or conversion with increasing water levels and more intense storms.

Warming water temperatures have made cold-water refugia locations more important for cold-water species (salmon and steelhead), but there has been no assessment of the locations, magnitude, or extent of cold-water refugia. And we have begun to integrate potential changes to our native vegetation communities into restoration designs.

We need to identify areas that will be lost with rising sea levels, or converted to other vegetation communities so that we can proactively incorporate these changes into our restoration designs now, and increase the long term success of our efforts.



Average August Water Temperature at Bonneville (1950-2015)
Columbia River DART, Columbia Basin Research, University of Washington

As the planet warms because of climate change, there are many predictions for longer, hotter, dryer summers; longer, hotter heat waves; and more, larger wildfires. These create a wide diversity of human health risks, from dehydration to breathing problems. Heat waves cause urban heat islands to "cook" air pollution into ground-level ozone or smog, which can make it difficult to breath, particularly for the elderly and for people with asthma or other lung diseases. Add to that the increases in smoke from the large wildfires we are now seeing. It's another example of how much of an impact climate change will have and how interconnected our landscapes are.

Changing our approach to environmental protection. What we are facing – environmentally, economically, socially - requires a shift in how we approach environmental protection. To date, we have developed most of our actions based on historical data and assessment of degradation or damage. For example, in the lower Columbia River and estuary, we have lost 114,050 acres of habitat since 1870, so we have developed expansive programs as a region and are investing millions of dollars to recover some of that. Climate change will require us to be proactive — to develop and take actions based not only on current conditions but on projections for conditions 10, 20, and 50 or more years out.

Actions based on what we are experiencing now.

Protect and restore cold-water refugia. Water in the lower Columbia River is warmer and for longer periods than it was historically. Currently the average summer water temperature is between 66 and 71°F with peaks up to 75°F. That's well above the 66°F limit for cold-water fish such as salmon and steelhead. For weeks or months every summer, salmon and steelhead migrating through the Columbia must locate to areas off the mainstem, at the mouths of cold-water tributaries, to find pockets of cool water where they can rest and feed.

By 2090, warming water temperatures and changes in precipitation and stream flow are expected to reduce the availability of habitat for cold-water species in the Columbia Basin by 20 to 40 percent.

Why this matters ...

To thrive, native fish such as salmon and bull trout need cold water. When temperatures get too warm, cold-water species become stressed and their behavior changes, making them more vulnerable to predators. Their physiology and reproductive development change, and they become less fit and more susceptible to disease. If the water gets too warm, they can die, as happened in the Willamette River in the summer of 2015.

Adapt now for changes in dissolved oxygen and acidification in the estuary. More and more, low-oxygen ("hypoxic") conditions are occurring in ocean waters off the continental shelves of Oregon and Washington. This typically happens during sustained periods of coastal upwelling. Scientists are finding that hypoxic ocean water is moving into estuaries, including the Columbia River estuary, through tidal exchange. A similar pattern is occurring with ocean acidification, as upwelled waters with low pH levels move from the ocean into our estuaries.

Sea level rise will increase the frequency of hypoxic and acidification conditions in the Columbia River estuary. As tidal exchange increases, these impacts will occur further up the lower Columbia.

Why this matters ...

Low-oxygen conditions can cause marine life to suffocate or be displaced, while acidification can change the estuarine food web. These conditions have the potential to worsen with changing climate patterns, which are shifting spring high flows to earlier in the year and causing lower summer river flows (allowing tides to move further into the estuary).

Integrate expected shifts in plant and animal species, habitat structure, and biological interactions into our management strategies. Temperature, precipitation, and CO_2 have direct, local effects on hydrology and soil processes in the lower Columbia River and estuary, and therefore on the survival, growth, behavior, and biological interactions of its plants and animals.

Based on studies completed in other areas of the west, we expect that changes in temperature, precipitation, and CO_2 will cause shifts in the vegetation and habitat conditions. We anticipate some vegetation species will not be able to adapt and will die off and become locally extinct. Other species, some new, will colonize and thrive in the new conditions. The changes to vegetative communities will alter the native food web, nesting, foraging and other conditions native fish and wildlife have acclimated to over the millennia. These shifts will, in turn, affect the ability of animal species to use those habitats, including birds, reptiles, amphibians, and macroinvertebrates.

Why this matters ...

With changing climatic conditions, current habitats may become unsuitable for many species, which will be forced to move to new locations. This can increase competition for limited habitat and food. Given the time it takes for new vegetation to become established, it makes sense to start incorporating expected changes into our management strategies now, so that native species have what they need as the estuary changes.

Reduce the amount of impervious surfaces and manage stormwater to reduce runoff. There are more and more impervious surfaces, such as rooftops, roadways, and parking lots, and less forested area in the lower Columbia River region. Between 2001 and 2010, the amount of land in the region that was covered by impervious surfaces increased by approximately 2.5 percent, and the amount of forested land dropped by almost 8 percent. These changes are a problem because impervious surfaces contribute to stormwater runoff, which degrades streams and rivers. Stormwater runoff from urbanized areas is one of the biggest challenges facing the lower Columbia River and its tributaries.

Climate change will compound the effects of impervious surfaces on local streams and rivers. Climate models for the Pacific Northwest predict less precipitation falling as snow and more falling as rain. That increased rain means more stormwater – especially if the amount of impervious surfaces continues to grow.

Impervious surfaces affect more than water quality. Roads, sidewalks, driveway, and roofs have a great capacity to absorb heat, particularly if they are dark. During summer months these surfaces can get 60 to 70 degrees hotter than more reflective surfaces or greenery, like trees and grasses. They can create urban heat islands—areas in the city that have noticeably warmer temperatures.

Why this matters ...

Stormwater picks up a variety of pollutants (many of them toxic) and delivers them to our waterways. With its concentrated flow, stormwater runoff can erode streamside vegetation and damage aquatic habitat. Also, because stormwater runoff is warm, it can load streams and rivers with warmer temperatures, or "thermal pollution." Stream degradation from stormwater runoff typically becomes acute if the impervious surfaces in the watershed exceed 25 percent of the land area.

To minimize water quality effects in the estuary, it will be important to proactively manage our stormwater. We can do that by using on-site infiltration techniques such as green roofs, permeable pavers, and infiltration swales. We also can take steps to reduce or control pollutants, so they don't get picked up by stormwater in the first place.

Reducing the amount of impervious areas also reduces the number and intensity of urban heat islands, which affect human health.

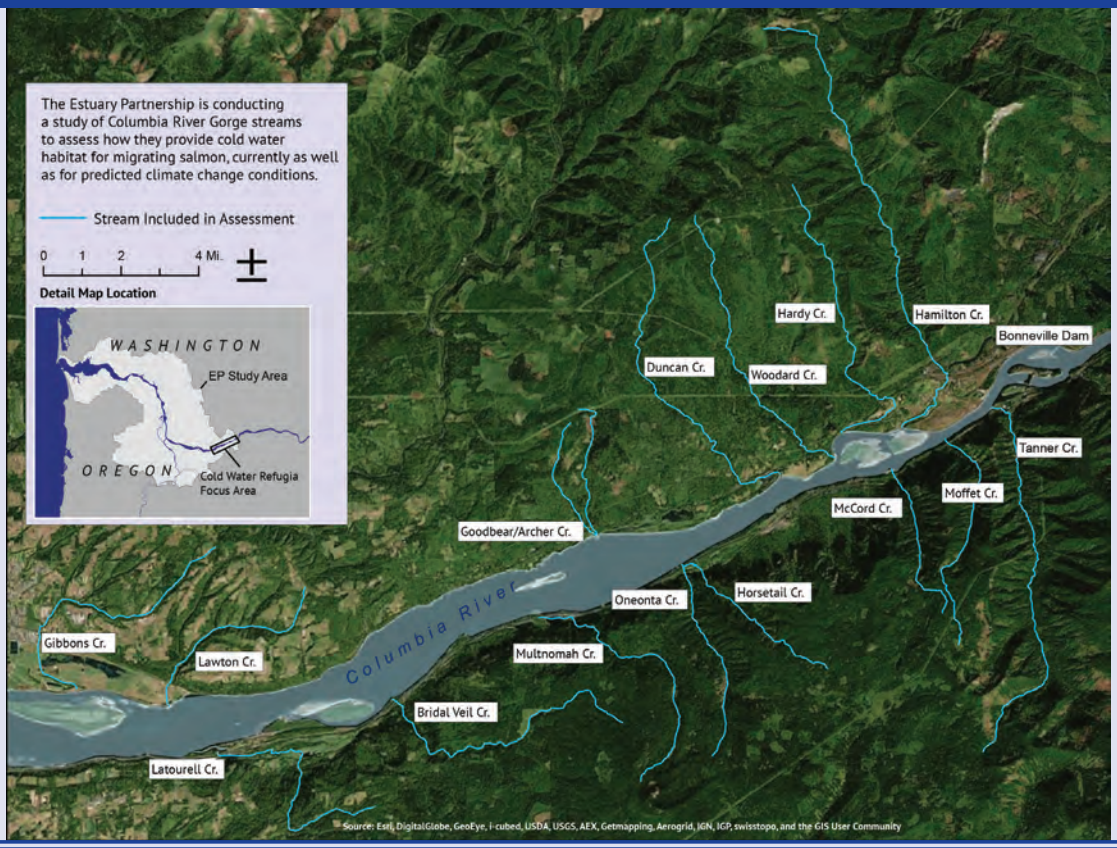
Use the data and projections we have and adjust and adapt. Resource managers and restoration practitioners typically focus on protecting current habitats or restoring historical habitats and conditions. But warming temperatures, rising sea levels, changing precipitation patterns, low oxygen levels and ocean acidification are reshaping ecosystem conditions in the estuary—fast. That means that what's happened in the past, and how quickly, is not necessarily a good predictor of the future.

It's time to change how we do things. Instead of responding to events as they occur, we need to anticipate them – to project what will happen in the future and plan accordingly. We need to start integrating information about the predicted effects of climate change into our protection, restoration, and species recovery actions now, to improve the likelihood that they will succeed over the long term.

We can start by doing things like protecting cold-water refugia for native fish by protecting base flows, removing diversions that dewater downstream areas, and planting trees to provide shade. We can start protecting the land behind current wetlands so wetlands have room to migrate inland as sea level rises. We can plant native trees and shrubs that are well-adapted to future precipitation and temperature conditions.

To implement these techniques, we will need to fill data gaps and develop specific scenarios that reflect the predicted, tangible impacts of climate change.

Cold Water Refugia Study for Columbia River Gorge Tributaries



Why this matters ...

Climate change is causing estuarine conditions to shift in new ways, at scales and speeds different from in the past. To protect the estuary for the long term, we need to start now in adjusting practices and, possibly, shifting resources. A proactive approach, with timely, informed decisions, will help us take actions that increase the resilience of the estuary's ecosystems.

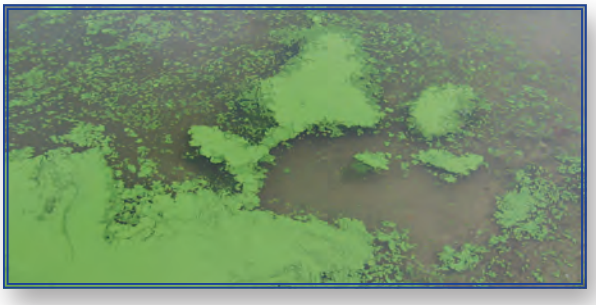
Actions to help us learn more.

Map sea level rise projections in the entire lower Columbia. Change land use patterns to offset expected losses of floodplain habitat. Preliminary research indicates that if sea level rises to a low estimate of 27 inches by 2100, the entire region of Puget Sound to Tillamook Bay, including the lowest 37 miles of the lower Columbia, would lose 12,355 acres of dry land. Additionally, 65 percent of its estuarine beaches, 44 percent of its tidal flats, 13 percent of its inland fresh marsh, 25 percent of its tidal fresh marsh, and 61 percent of its tidal swamp habitats, amongst yet others, would all be lost through submersion and conversion. Predicted changes in precipitation could compound matters, by reducing snowpack, spring river flows and the inundation of remaining floodplain habitats.

Why this matters ...

Natural floodplain habitats, such as forested tidal swamps, support aquatic species throughout their life history but are particularly important during ecologically important times, such as reproduction, rearing, and migration. Pacific Northwest estuaries are highly productive areas of special importance to resident and migratory populations of shorebirds, waterfowl, and raptors, as well as 75-90 percent of all commercially and recreationally harvested fish. Within these estuaries, many critical physical processes and essential ecological functions occur, including stormwater management and flood control; trapping of sediments and non-point source pollutants by marshes and eelgrass beds; and rearing, foraging and nesting for birds, fish, and marine mammals. These habitats are also highly recognized as nursery sites and transitional zones for juvenile crabs, shrimp, bottom fish, and juvenile salmon and steelhead.

Find out whether toxins from cyanobacteria bioaccumulate in the aquatic food web, and how they affect fish, wildlife, and birds. Beaches and lakes sometimes close because of toxins produced by blooms of cyanobacteria, or blue-green algae. This happened in the lower Willamette River in 2014 and 2015, for example, and occurs almost yearly in Vancouver Lake. Typically cyanobacteria blooms occur when the water in nutrient-rich, poorly mixed bodies of fresh water, such as freshwater lakes or slow-moving streams, warms up.



It is likely that, as the water in our lakes and rivers warms as a result of climate change, cyanobacteria blooms will become more common.

Why this matters ...

Some cyanobacteria produce toxins, such as heptatoxins (which affect the liver) and neurotoxins (which affect the nervous system), that can harm or kill organisms that are exposed to them. We don't yet know how these toxins affect native species or whether they bioaccumulate up the food chain. We also don't understand why some cyanobacteria blooms produce toxins and others do not. It will be important to better understand the production and effects of cyanotoxins if exposures increase because of the changing climate.

Toxic Contaminants

"Investments to reduce toxics and clean up small hot spots in the Columbia Basin lag far behind other large aquatic ecosystems."

Toxics are ubiquitous in the Columbia River Basin. They harm plants, animals, our families, our economy and our quality of life. The toxics come from many sources and activities and the impact is the result of the cumulative use of many toxics over a long time. Many accumulate up the food chain posing significant threats to human health.

The impact is acute. Thirteen species of salmonids are listed as threatened or endangered. Salmon are an indicator for other species' health and demonstrate the consequences of habitat degradation and the increase in toxics exposure. Toxic contaminants in the estuary are interfering with the essential biological functions of ESA-listed salmon and steelhead, potentially inhibiting their recovery. They are not alone; many other species—other fish, native plants, birds, and mammals—are impacted by toxics.

Investments to reduce toxics and clean up small hot-spots in the Columbia Basin lag far behind other large aquatic ecosystem, as designated by US EPA. Current funding levels cannot address the magnitude of the threat to the Basin – the problem is too large, comes from too many sources and needs federal investment and attention. The Estuary Partnership – with many partners around the Basin - is working with Congress to pass the Columbia River Basin Restoration Act to bring funds to the region for toxics reduction and build on the many successful efforts already underway.

Issue: Toxic Contaminants and Water Quality

Once in the water, toxic contaminants enter the bodies of organisms. These contaminants are bioaccumulating up the food chain and reaching concentrations that affect the health of fish and wildlife—and people.

Issue: Toxic Contaminants and Habitat

We are not evaluating potential restoration sites for toxic contaminants, and toxics accumulate in sediment, as well as stay in the water column. So we may be restoring sites that are contaminated. This puts fish and other species at risk of additional exposure to toxics.

Issue: Toxic Contaminants and Human Health

Contaminant	Effects
Mercury	Neurological problems Developmental problems Reproductive problems
DDT	Cancer Liver disease Hormone disruption
PCBs	Immune system damage Increased cancer risk
Flame retardants (PBDEs) Personal care products Pharmaceuticals	Hormone disruption Increased cancer risk Birth defects Learning disabilities

Fish advisories issued for the middle Columbia Basin now advise limiting consumption of resident fish. Native Americans in the Columbia River Basin eat 9 to 12 times more fish than the general public does, and Russian and Asian populations eat lots of sturgeon, which feed on the river bottom where contaminants settle. The fish consumption patterns of people in these groups put them at increased risk of health impacts from exposure to toxic contaminants.

Issue: Toxic Contaminants and Economic Impact

Toxic contaminants have economic impacts as well. Lands contaminated with toxics cannot be used until they undergo costly cleanup. Some port and marina operations along the lower Columbia River are hindered by contaminated dredge materials. Contaminated species affect economic viability of fishing industries and other industries.

Issue: Toxic Contaminants and Land Use

Stormwater runoff, especially in areas with high populations and businesses, is a toxic soup. Stormwater can contain some of the most common toxics, such as PCBs, PBDEs, pesticides, ingredients in personal care products and pharmaceuticals, etc., as well as other contaminants, such as pet waste and PAHs, the waste emitted from incomplete combustion of petroleum-based engines.

Issue: Toxic Contaminants and Species

Contaminant	Effects
PBDEs	• Impaired reproduction
PCBs	• Impaired metabolism • Impaired thyroid function • Impaired reproduction
Mercury, ammonia, bacteria, DDE, DDT, dioxin, PCBs, and arsenic	• Increase mortality and disease susceptibility • Impair the reproductive organs of male river otters • Thin the eggshells of osprey and bald eagles, reducing reproduction in some areas by half
DDT and pesticides	• Concentrate in top predators such as bald eagles, reducing reproduction
Flame retardants (PBDEs) Personal care products Pharmaceuticals	• Male fish morphing into female fish • Impaired reproduction • Disease susceptibility • Difficulty avoiding predators

What We Can Do

Collectively, individual actions make a big difference.

Our choices affect the ecosystems around us. Whether at home, at work, or as a community, we all can make changes to improve the state of the estuary. Even a single action can have effects in many areas. If we use fewer fertilizers or pesticides, for example, we save money, we decrease our daily exposure to toxics, we put fewer toxics into the water, and we spend less money trying to recover endangered fish species, repairing human health, or cleaning up toxic hot spots.

Taking action influences what people around us do and our peers notice. These changes also create new markets that have minimal impact on our environment.

Collectively, individual actions make a big difference. Getting the changes we need in water quality and habitat will take many actions, by us all, in all aspects of our lives–our personal choices, our business practices, and our public policy decisions. To correct past mistakes and face the growing challenges ahead, we need to step up some of those changes. Most of them aren't new, we have heard about them for decades. Already, we have achieved great successes across all sectors. We just need to do more. The more we can change our actions, the less we will have to spend repairing the damage—to our environment, to our economy, and to our health.

It is time to adapt our practices, expand our successes and adjust our approaches to do less harm.

What are things we can do more of as individuals, businesses, and governments ...

... to improve water quality and protect species (including people)?

- Use less toxic products. Products to watch for include:
  - pesticides and fertilizers (use targeted spraying), insecticides and herbicides
  - pest poisons, fungicides, and wood preservatives
  - drain openers, grease and rust solvents, and wood and metal cleaners
  - latex and oil-based paints, paint thinners, and paint strippers.
- Use pharmaceuticals and personal care products that are safe, and use less of them so they do not get into the water system in the first place. Many ingredients in pharmaceuticals and personal care products alter hormone balances, metabolism, and neurologic behavior in many species.
- Drop off unused pharmaceuticals and household hazardous waste at collection events.
- Buy green cleaners, office supplies, and building supplies.
- Clean up outdoor pet waste, which runs into our sewer systems.
- Drive less and maintain our vehicles to prevent oil or other fluid leaks.
- Sweep and rake leaves instead of using gasoline or electric blowers. It keeps lots of toxics created through petroleum combustion from entering the air. Pick up yard and sidewalk debris, rather than washing it into storm drains.
- Clean up toxic hot spots to re-use already developed land. Conserve open spaces.
- Employ closed-loop industrial processes to eliminate discharges and waste.
- Ban harmful chemicals and invest in green chemistry to design products and process that minimize the use of toxics.
- Increase commitment—and funding—to measure and reduce toxics. Monitor water, fish, and sediment so that we know which toxics are where, and at what levels.

... to reduce stormwater impacts on rivers and streams?

- Let the earth breath: Use permeable pavers for driveways and patios, build a rain garden, or install an ecoroof to decrease stormwater runoff.
- Plant more trees and leave native vegetation in place—especially along water bodies, where native plants will help filter runoff.

- Build low-impact development, whose green infrastructure features (such as bioswales) capture runoff on site so that it does not reach local waterways.
- Site new development outside of floodplains and other flood-prone areas. Require buffer areas along water bodies.
- Allow only water-dependent uses, such as boat ramps and ports, in the floodplain.
- Encourage land uses that are pedestrian-oriented. Promote transit-oriented development.

... to protect habitat for all species?

- Leave natural ground cover (e.g., old or dead wood) and native aquatic vegetation in our backyards and garden ponds.
- Protect amphibians and other native species from cats and dogs, who can disrupt amphibians' breeding activities.
- Do not use pesticides. Pesticides kill amphibians and the insects they eat, alter hormone balances in fish, affect neurologic development in humans, and cause cancer.
- Do not to disturb roosting or hibernating bats.
- Require buffers and plant native trees and shrubs along streams to create habitat, provide shade, and attenuate pollution.
- Protect upland habitat to accommodate sea level rise.
- Include toxics reduction in restoration and species recovery programs.

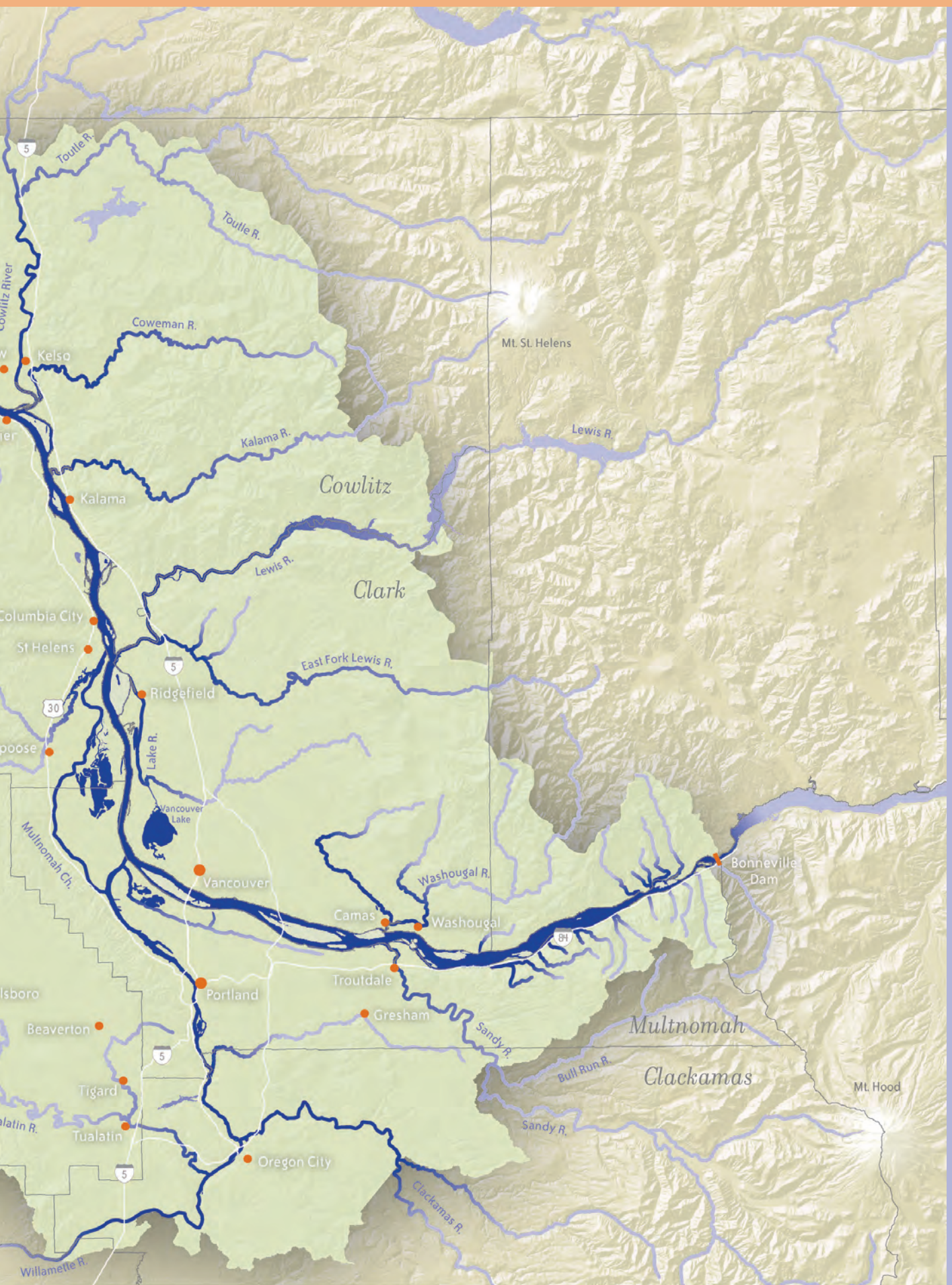
... to adapt to and mitigate the effects of climate change?

- Get specific data on how climate change is projected to affect the lower river and estuary and its communities.
- Incorporate those projections into building and development practices.
- Integrate climate change into restoration and monitoring efforts. For example, protect and restore cold-water refugia, cold areas in a stream, which are important to fish habitat as water temperatures continue to warm.
- Reduce energy consumption by turning down the heat in the winter and setting the air conditioning temperature higher in the summer. Conserve energy. Turn off lights and unplug electrical items when not in use. Buy energy-efficient appliances. Seal and insulate buildings. This reduces coal, petroleum, and hydropower use.
- Use water efficiently. Conserve water by fixing drips and leaks and installing low-flow shower heads and toilets. Don't over-water the yard. Choose native flowers, shrubs, and trees, which typically require less water.
- Use less. Reduce, reuse, and recycle. Find new ways to use old things, give used items to people who can reuse them, and send materials to recycling centers.
- Require energy-efficient development in our communities.
- Pay attention to unintended consequences. Reduce indirect uses of energy, such as bottled water, which takes more energy to produce and transport than municipal water does. (Disposing of the empty bottles also uses energy.) Or buy locally rather than online: Shipping to each of us individually uses much more energy than buying what has already been shipped in bulk to our area.


Pacific
Grays R.
Wahkiakum
Ilwaco
Cathlamet
Astoria
Warrenton
30
Longview
Clatskanie
Rain
Clatskanie R.
Youngs R.
Lewis & Clark R.
Pacific Ocean
N
Clatsop
Columbia
Scap
Washington
Legend
Cities
Major Roads
County Lines
Estuary Partnership Study Area Extent
Columbia River Basin
Washington
Oregon
Idaho
MT
NV
WY
Lower Columbia Estuary Partnership
www.estuarypartnership.org
0
5
10
15
20 Miles

Lower Columbia River and Estuary

Lower Columbia Estuary Partnership Study Area



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Lower Columbia Estuary Partnership

The Estuary Partnership was created in 1995 by the Governors of Oregon and Washington and the US EPA to provide regional coordination, to advance science, and to get on-the-ground results in the lower Columbia River and estuary.

The mission of the Lower Columbia Estuary Partnership is to improve the lower Columbia River by protecting and restoring ecosystems and enhancing clean water for current and future generations of fish, wildlife, and people. The Estuary Partnership Comprehensive Conservation Management Plan, with its 17 actions, directs the region with specific targets for habitat restoration, land use practices, water quality, contaminant reduction, student and community engagement, data and information, and regional coordination. The Management Plan is a long-range regional plan, developed collaboratively, directing activities to ensure the long-term health of the ecosystem.

Management Plan goals include:

- Increase habitat and habitat function for multiple species; restore 19,000 acres of habitat by 2014, and 25,000 by 2025.
- Conserve land to protect water quality and habitat; reduce impacts from land use practices; reduce armored shoreline by 10 percent by 2025; maintain impervious surface at no more than 15 percent.
- Reduce or remove contaminants and clean up contaminated sites to improve water quality.
- Provide education and engagement activities and provide data and information for a range of audiences; reach 5,000 students each year and host at least ten volunteer events each year.
- Convene and coordinate partners to enhance regional strategies and partnerships and heighten protection of the lower Columbia River.

The lower Columbia River and estuary is an "Estuary of National Significance," one of only 28 National Estuary Programs (NEP) in the nation. The US EPA administers the NEP, created by Congress in the 1987 amendments to the Clean Water Act to create collaborative, locally driven programs that address the physical, chemical, social, biological, economic, and cultural considerations for conserving and restoring our nation's estuaries.

The Lower Columbia Estuary Partnership operates as an independent 501(c)3 non-profit corporation for public benefit with the purpose of protecting the lower Columbia river and estuary. The Estuary Partnership Board of Directors represents the diverse interests and geography of Oregon and Washington. The Board is the governing body for the organization.

US EPA and the States of Oregon and Washington have funded the Estuary Partnership since 1995. From that we leverage other public and private funds to implement all programs and activities. Hundreds of corporations, foundations, agencies of governments, tribes, conservation entities, and individuals are active contributors and partners.

Lower Columbia Estuary Partnership

Advancing science, protecting ecosystems, building connections to sustain the Columbia for all time.

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