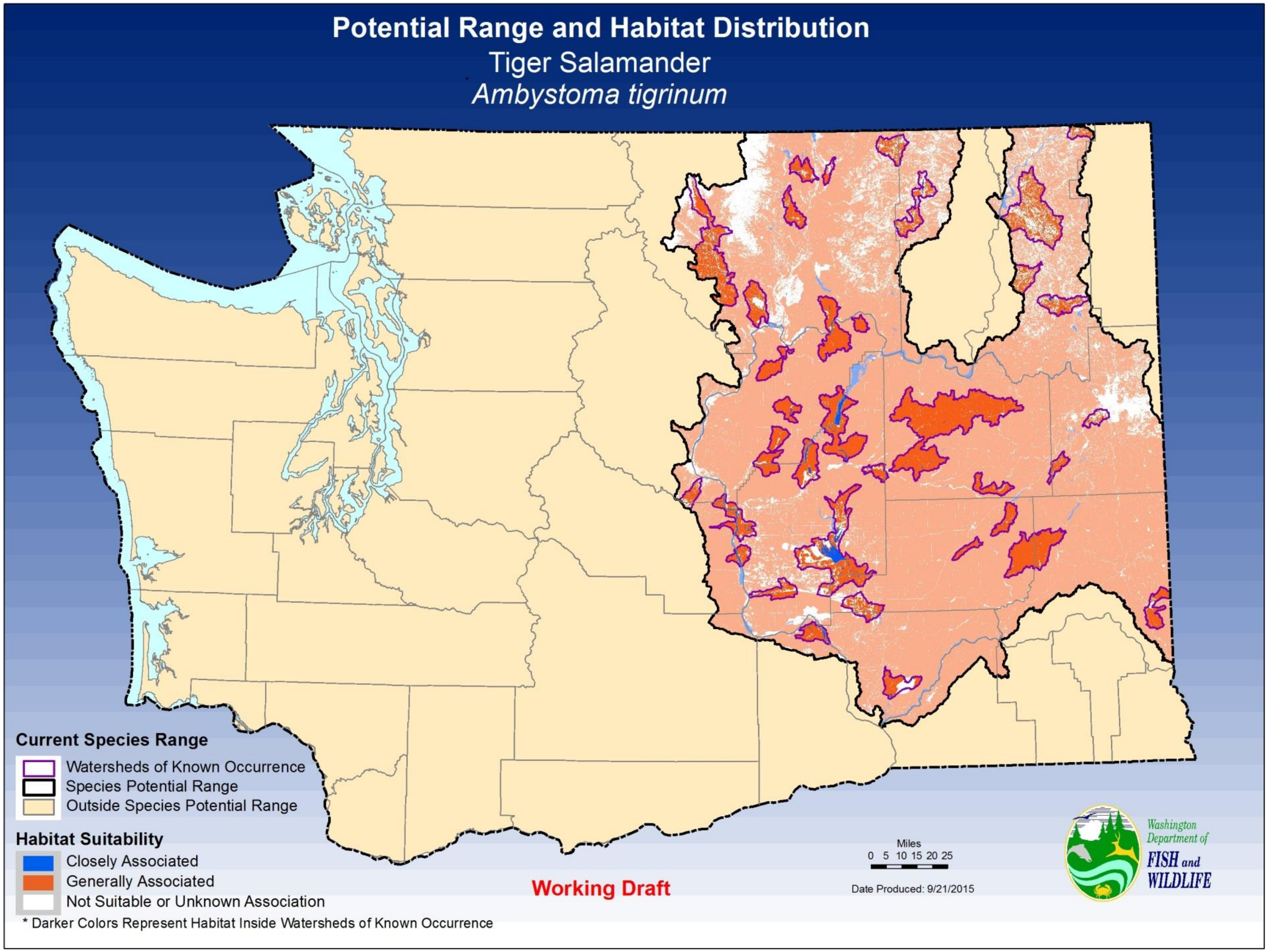
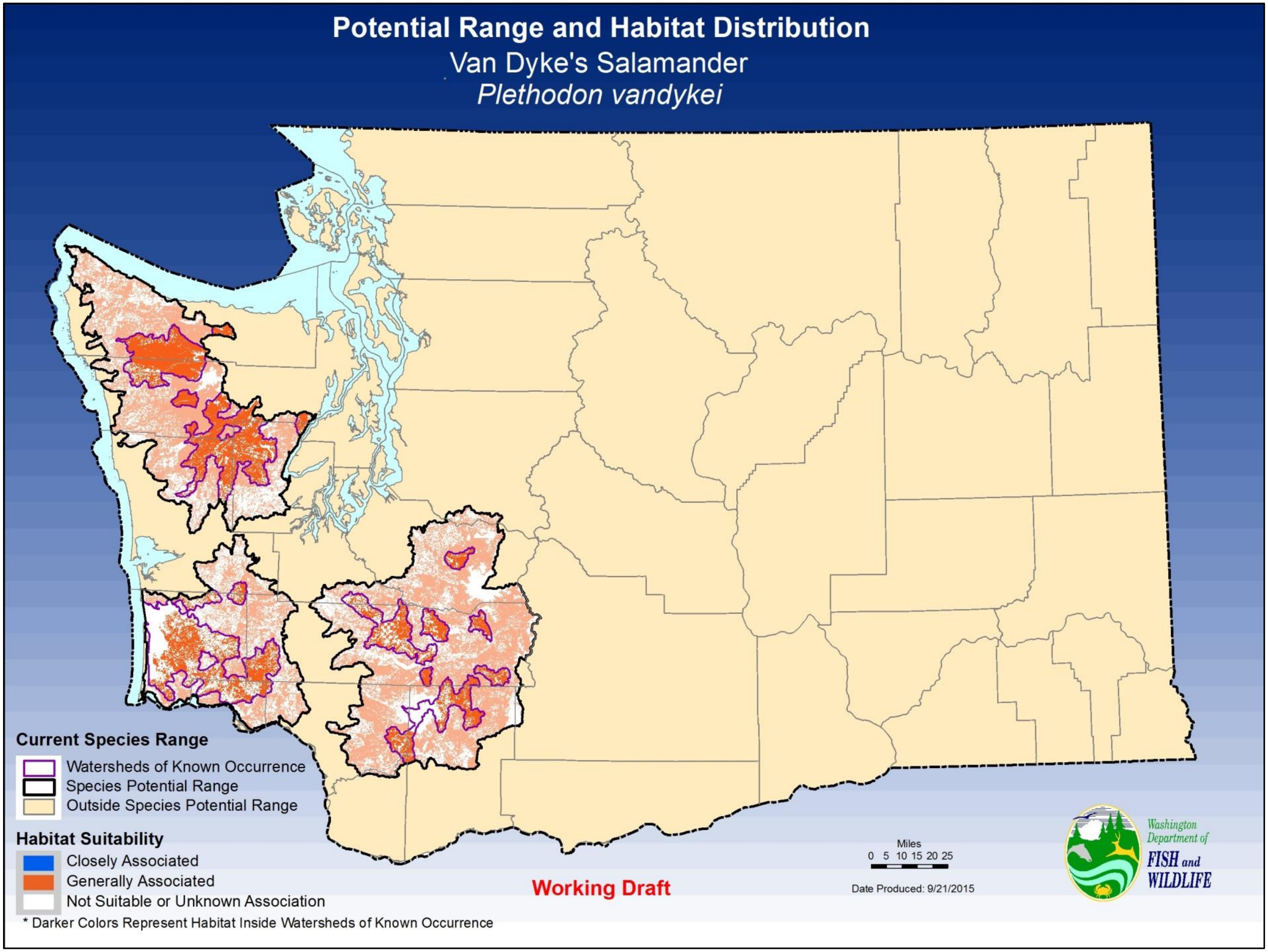
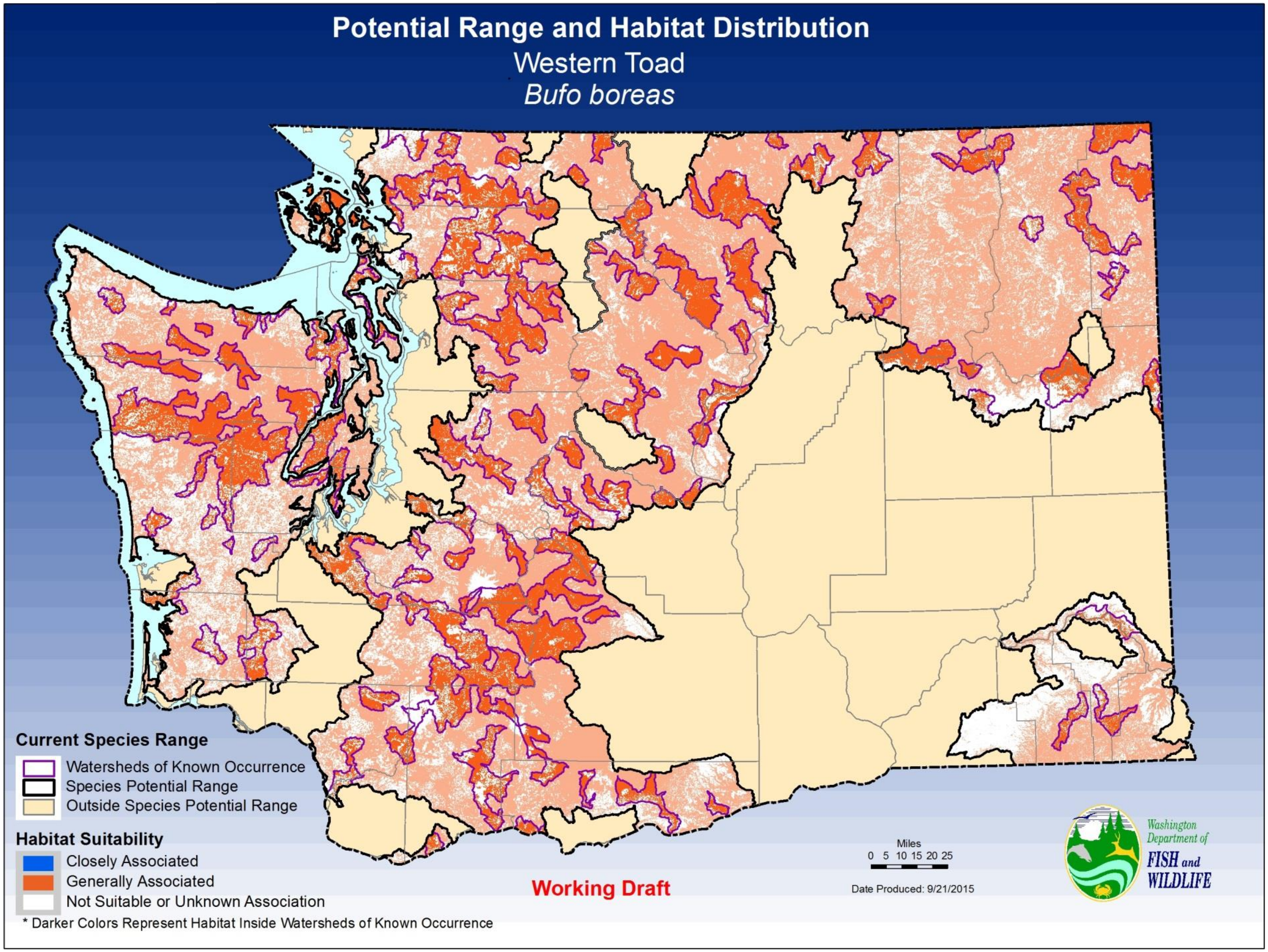
Tiger Salamander



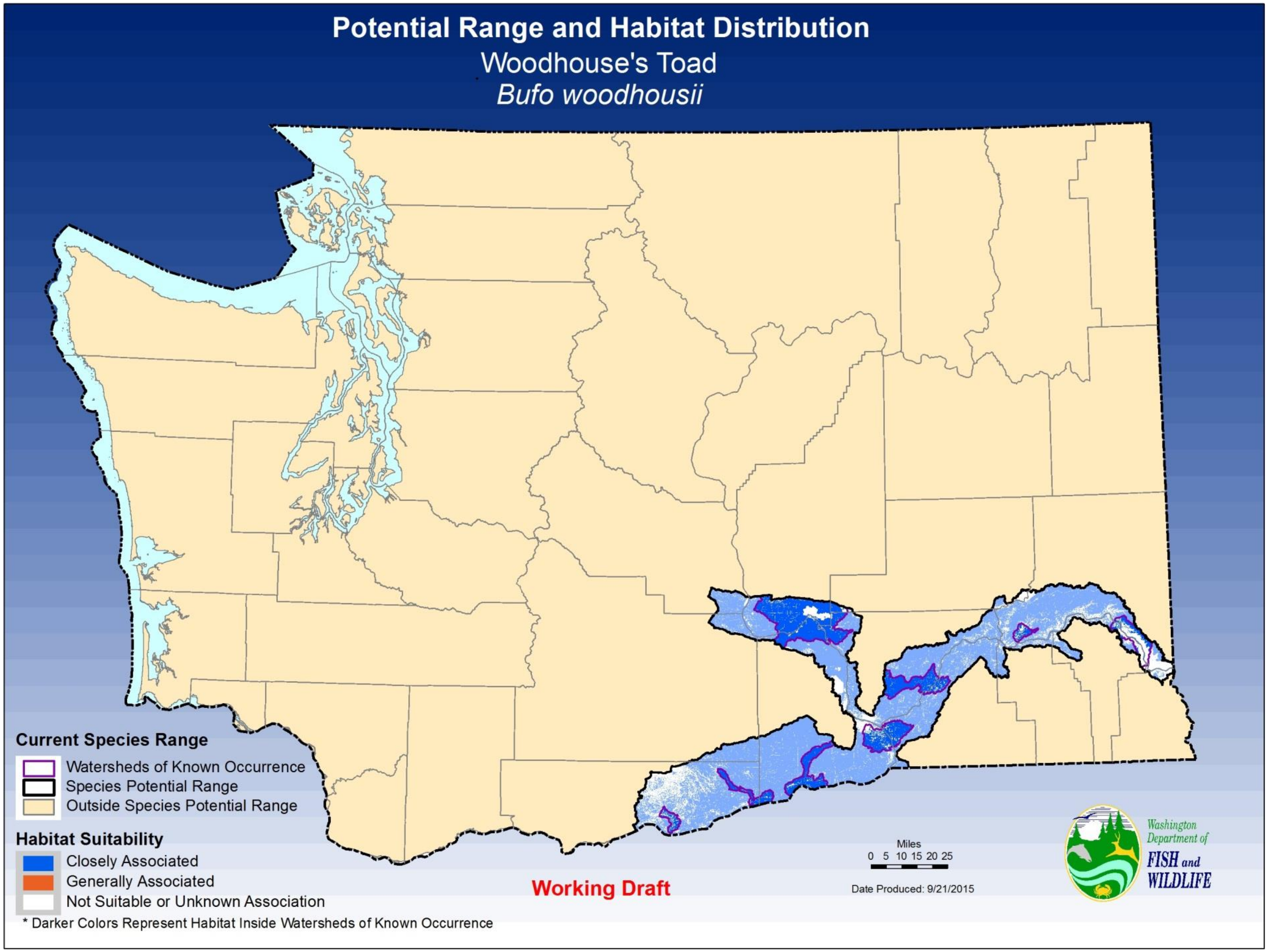
Van Dyke's Salamander



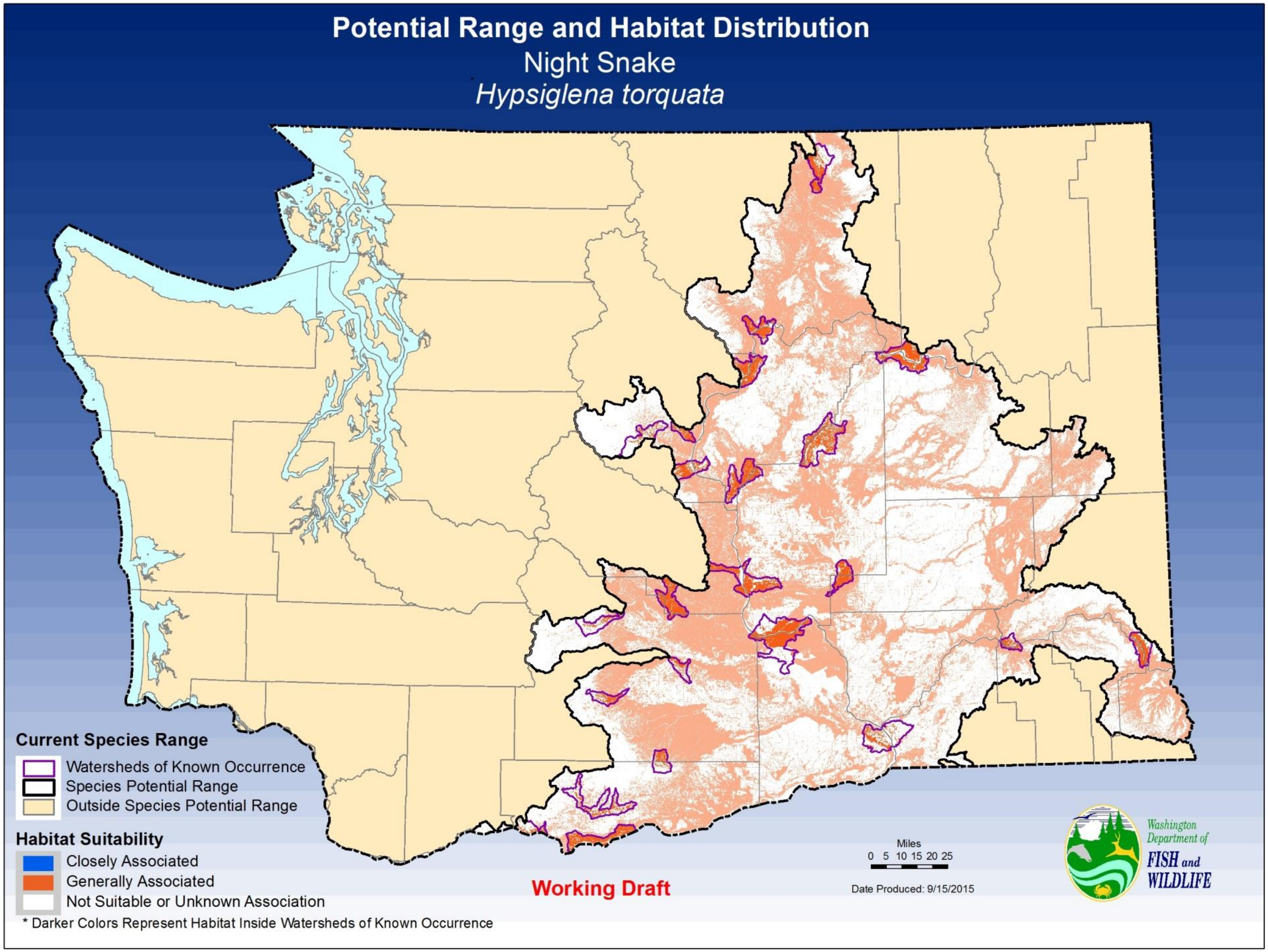
Western Toad



Woodhouse's Toad

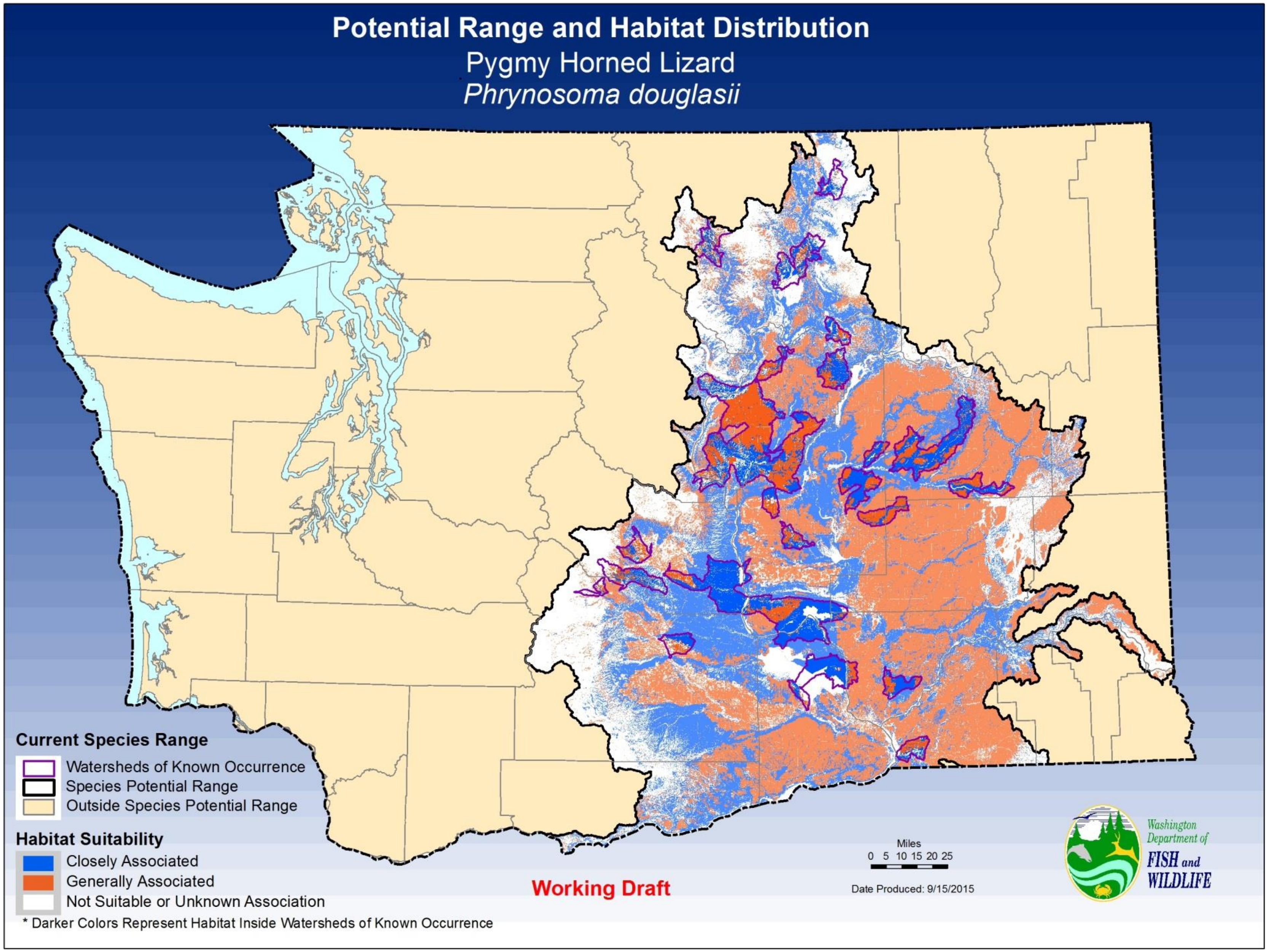


Night Snake

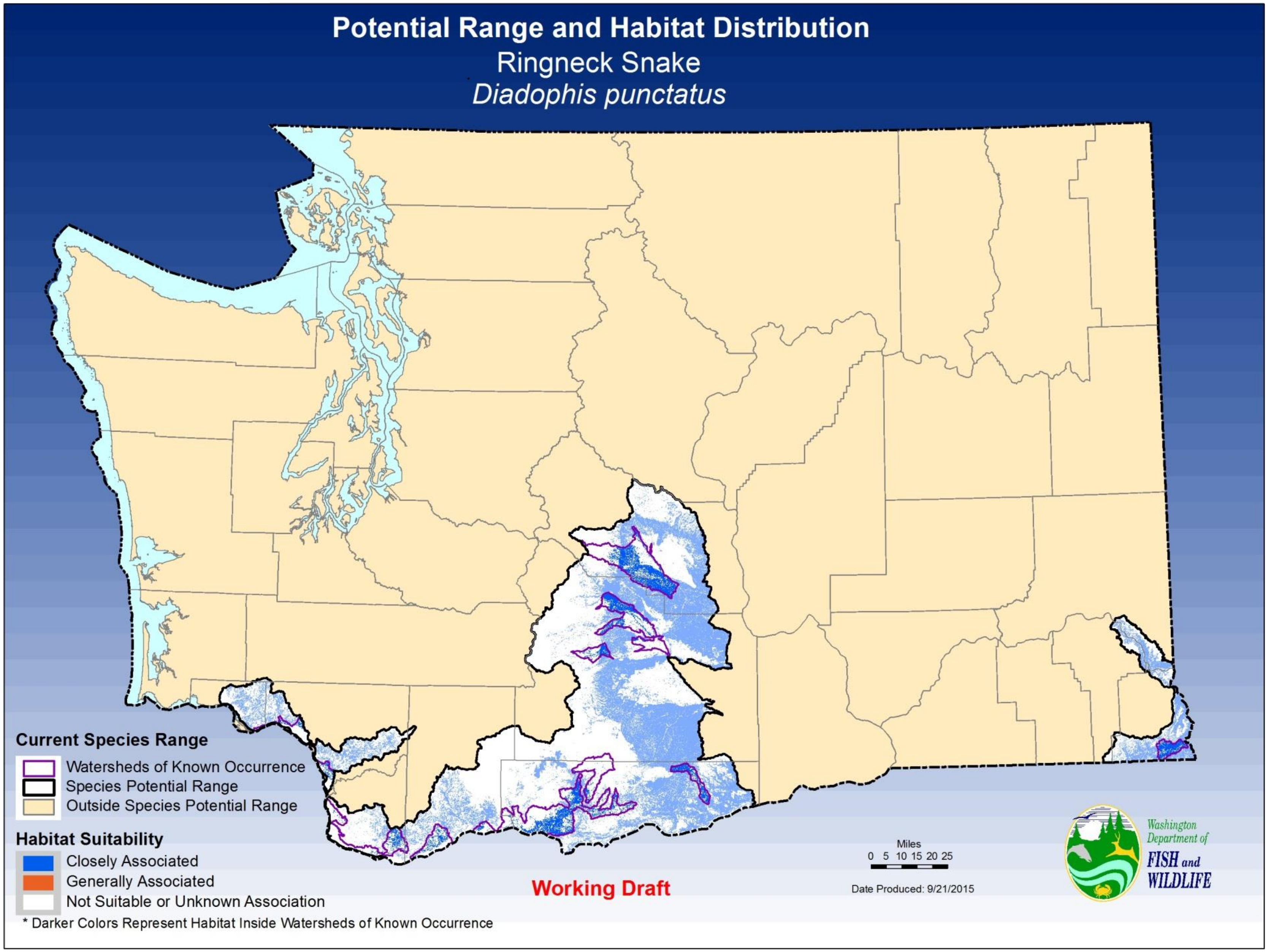


Potential Range and Habitat Distribution
Night Snake
Hypsiglena torquata
Current Species Range
Watersheds of Known Occurrence
Species Potential Range
Outside Species Potential Range
Habitat Suitability
Closely Associated
Generally Associated
Not Suitable or Unknown Association
* Darker Colors Represent Habitat Inside Watersheds of Known Occurrence
Working Draft
Miles
0 5 10 15 20 25
Date Produced: 9/15/2015
Washington Department of FISH and WILDLIFE

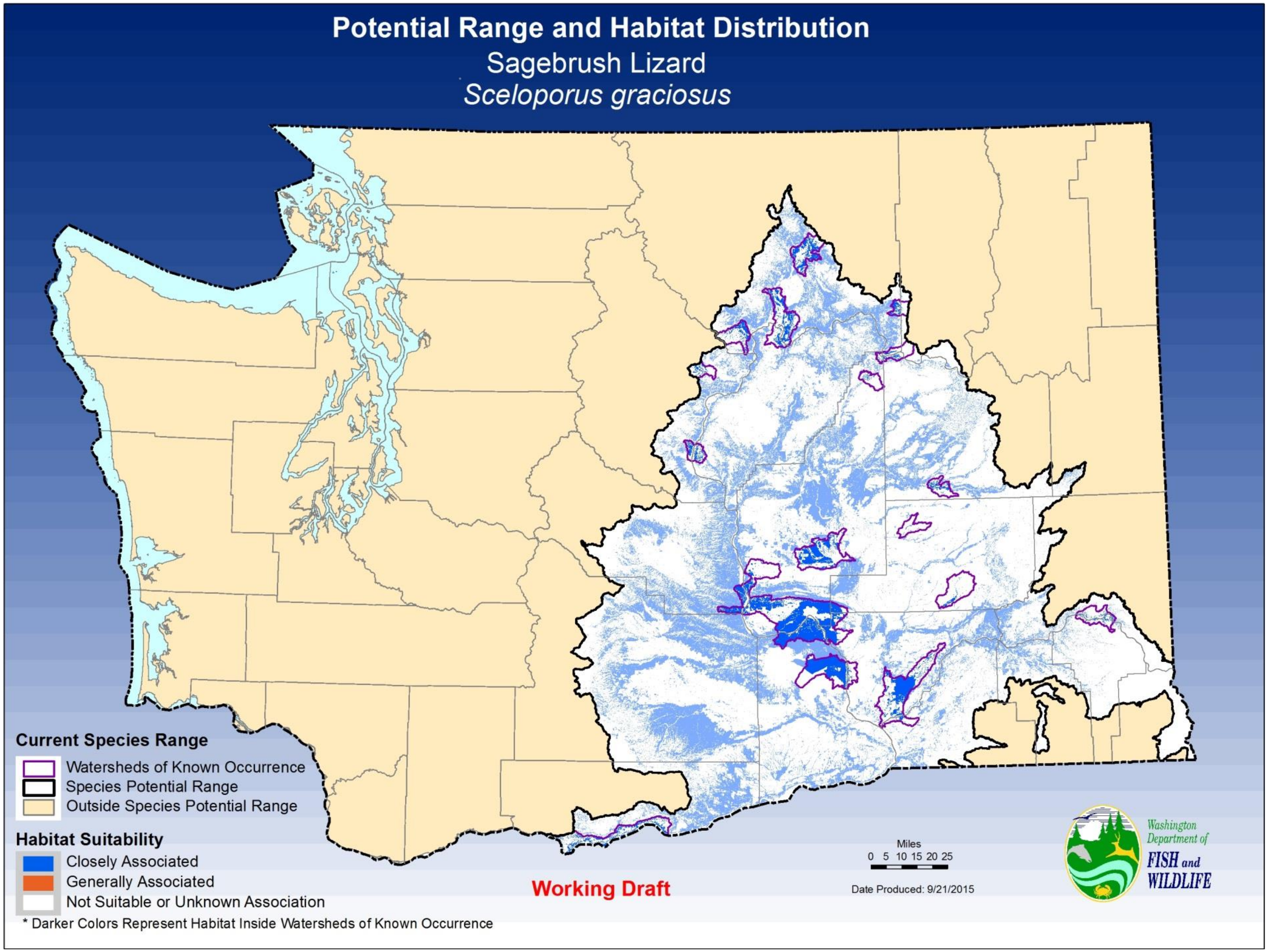
Pygmy Horned Lizard



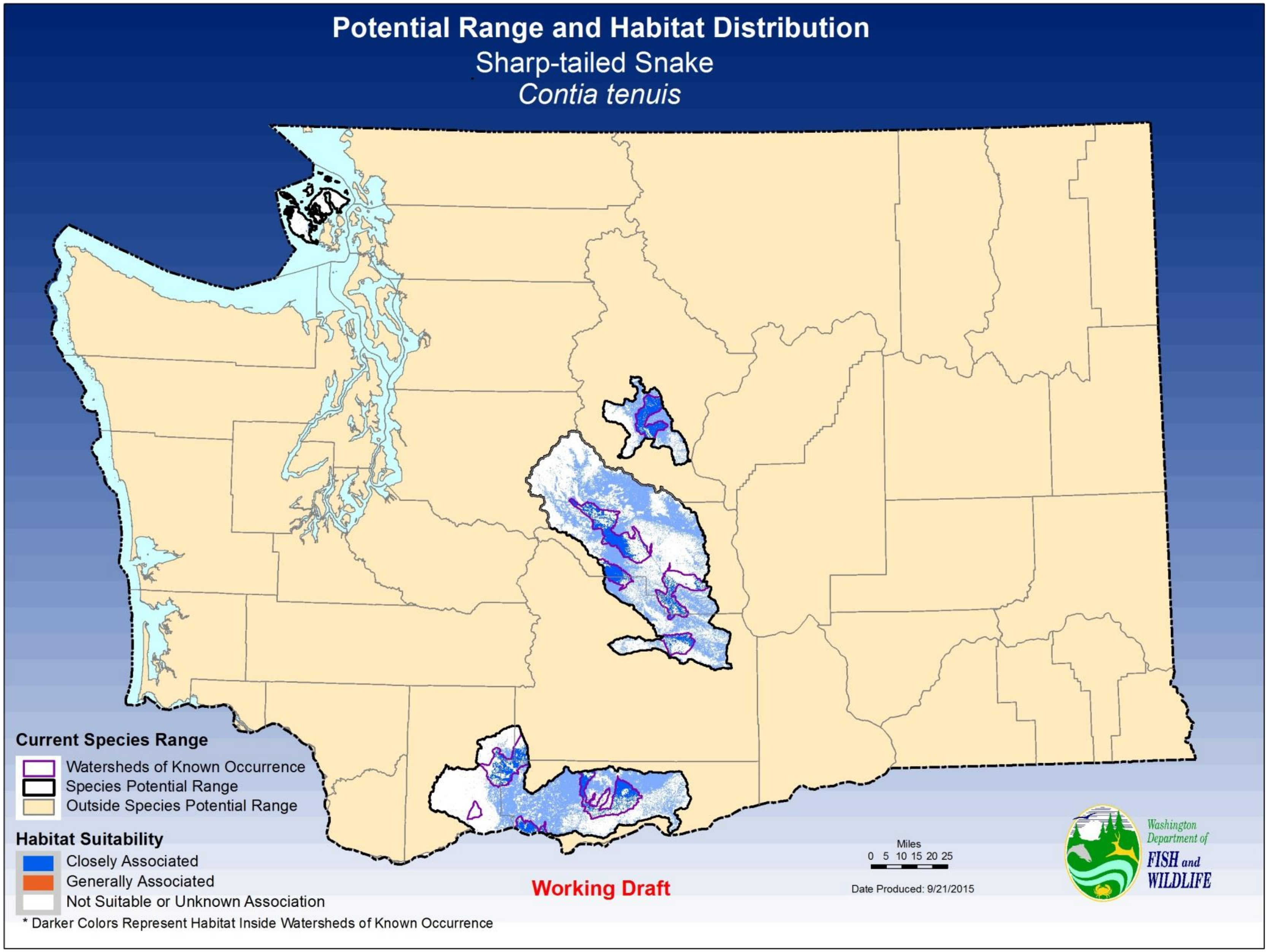
Ringneck Snake



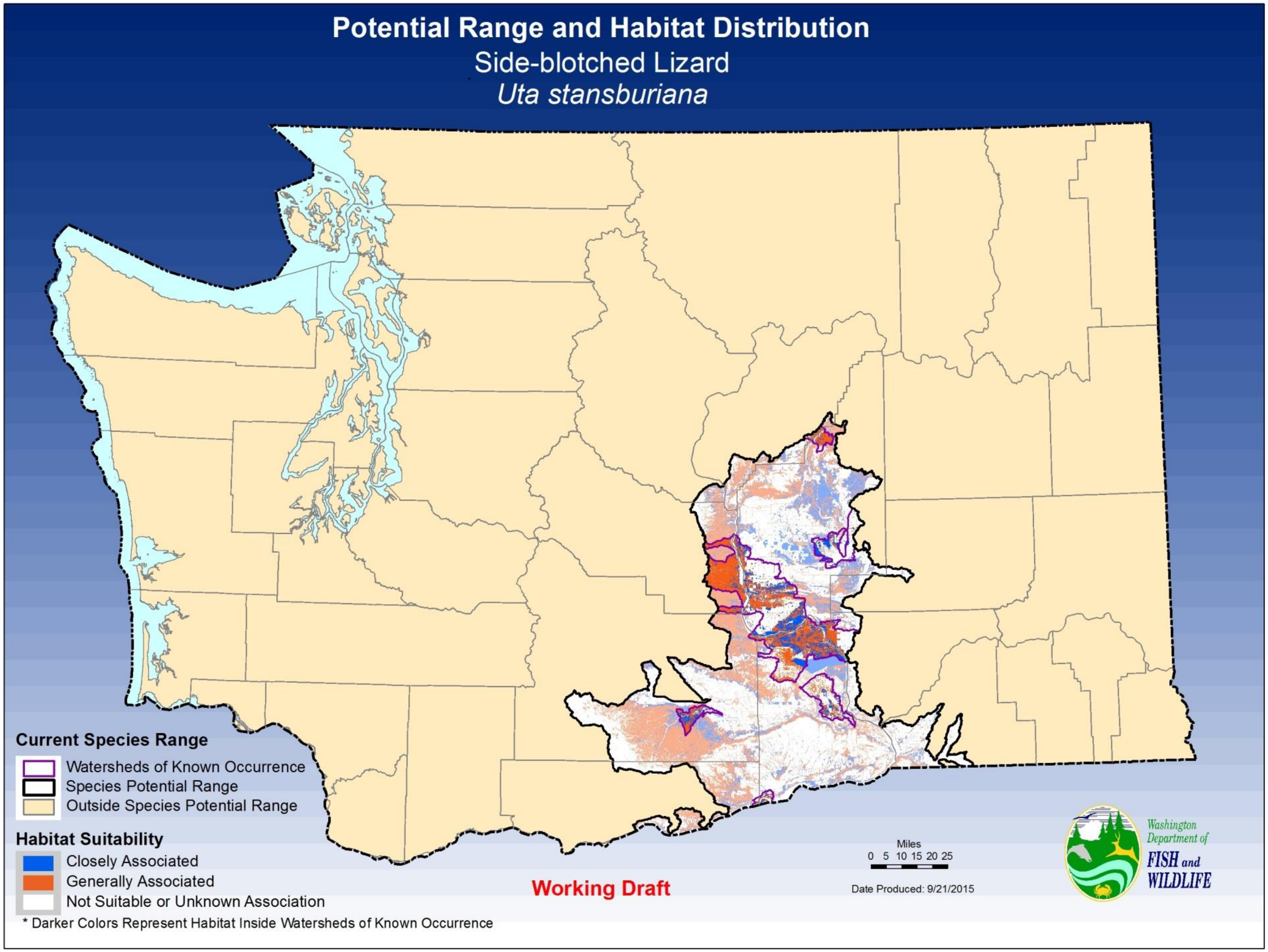
Sagebrush Lizard



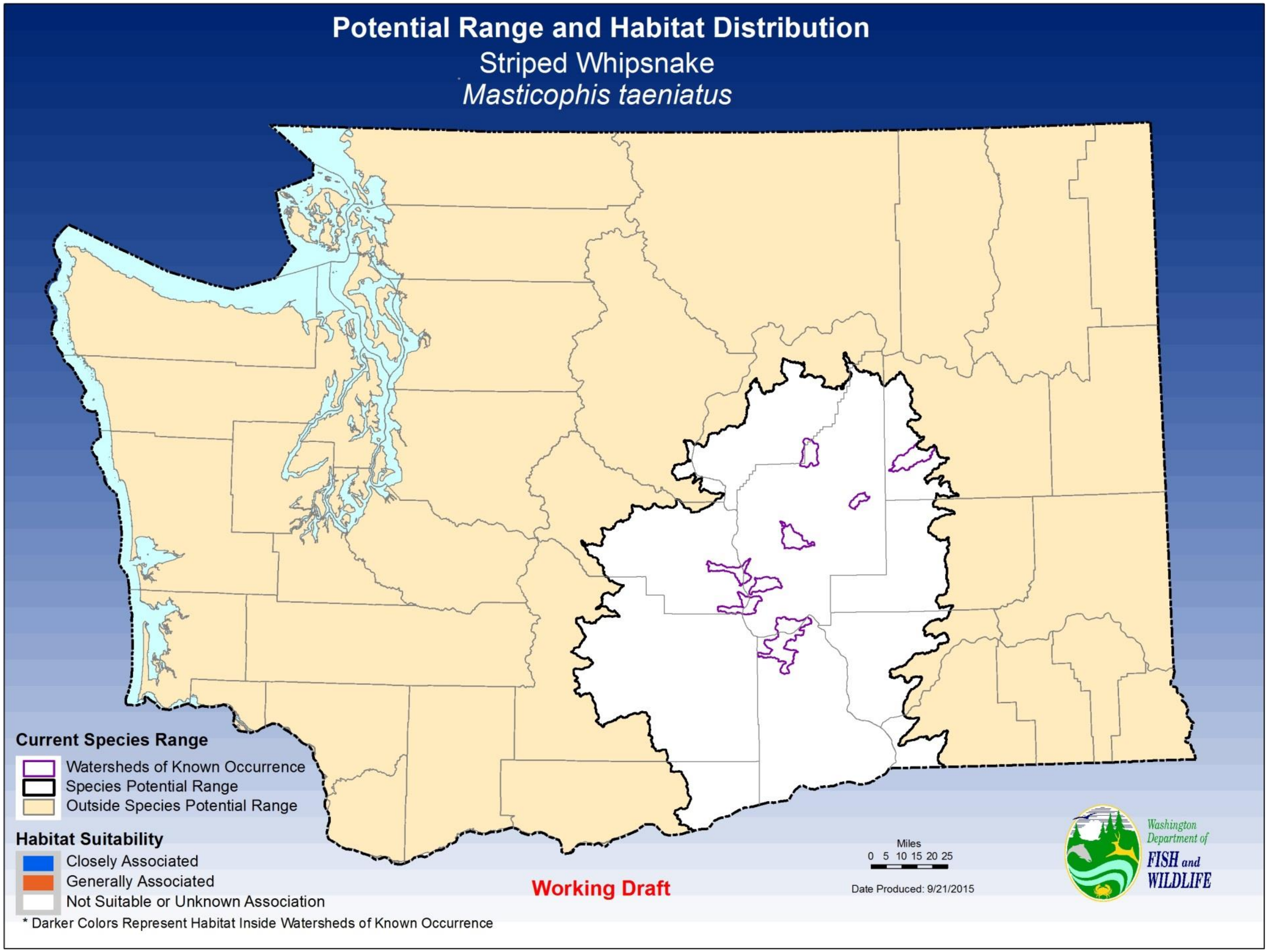
Sharp-tailed Snake



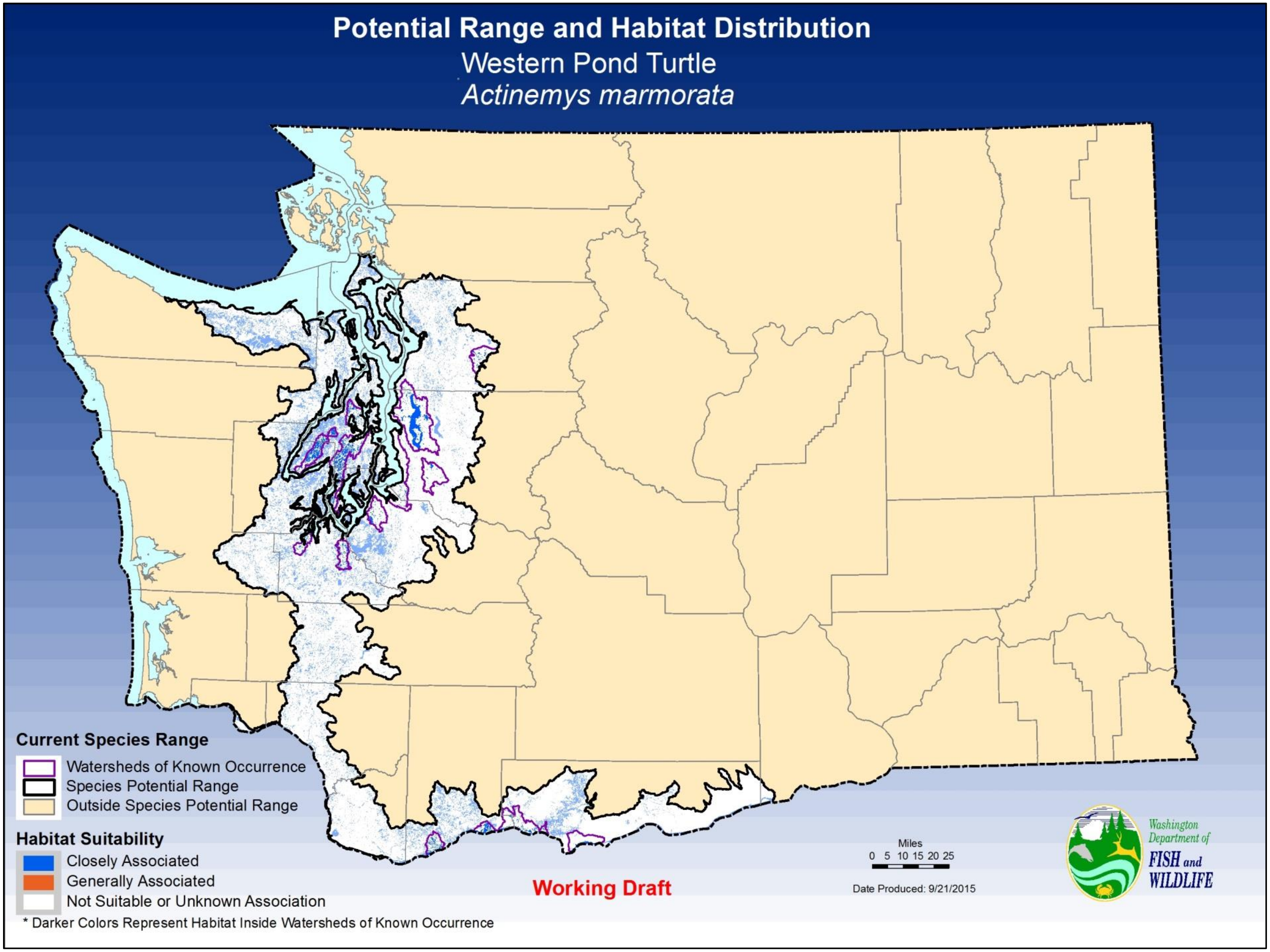
Side-blotched Lizard



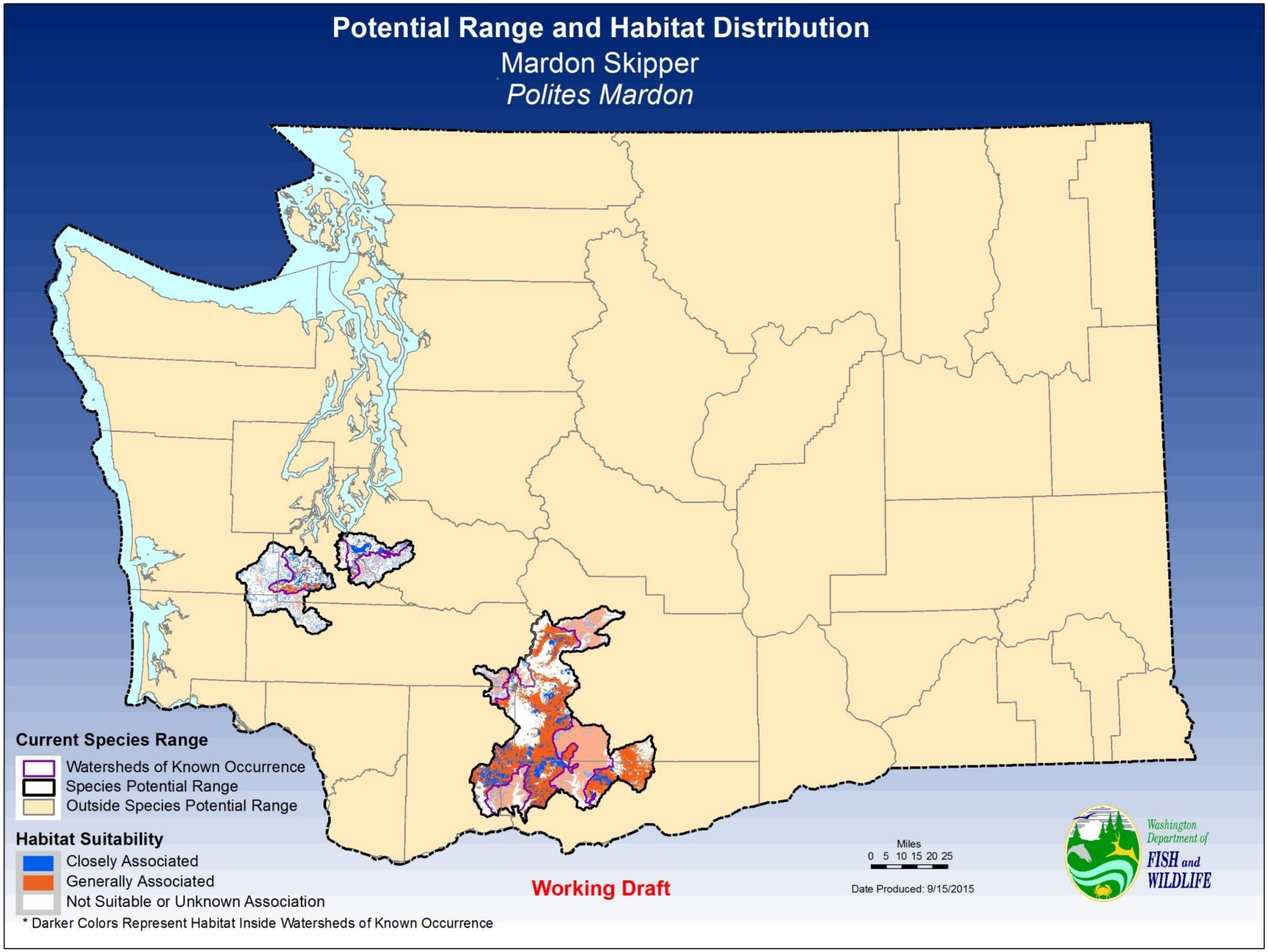
Striped Whipsnake



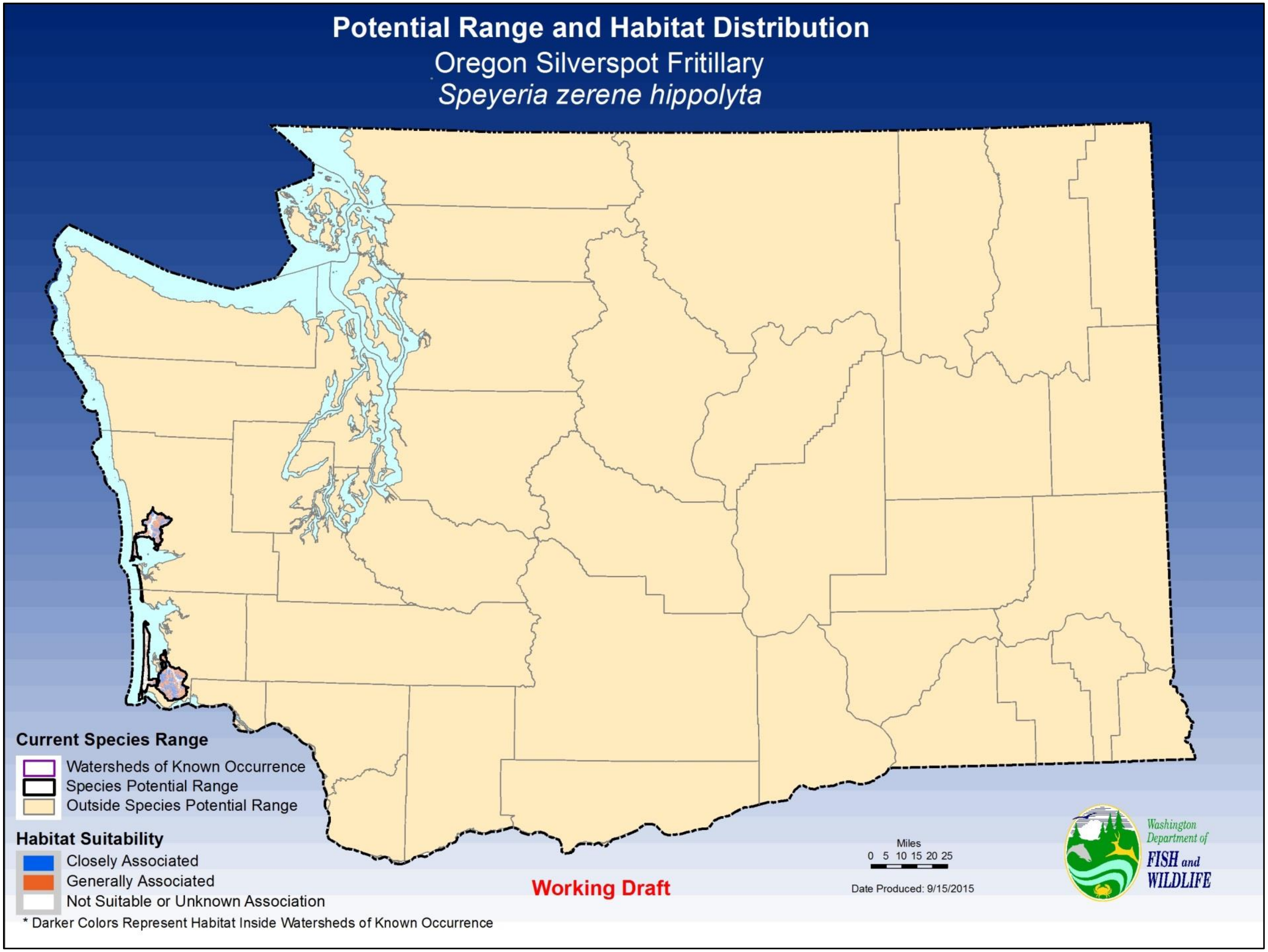
Western Pond Turtle



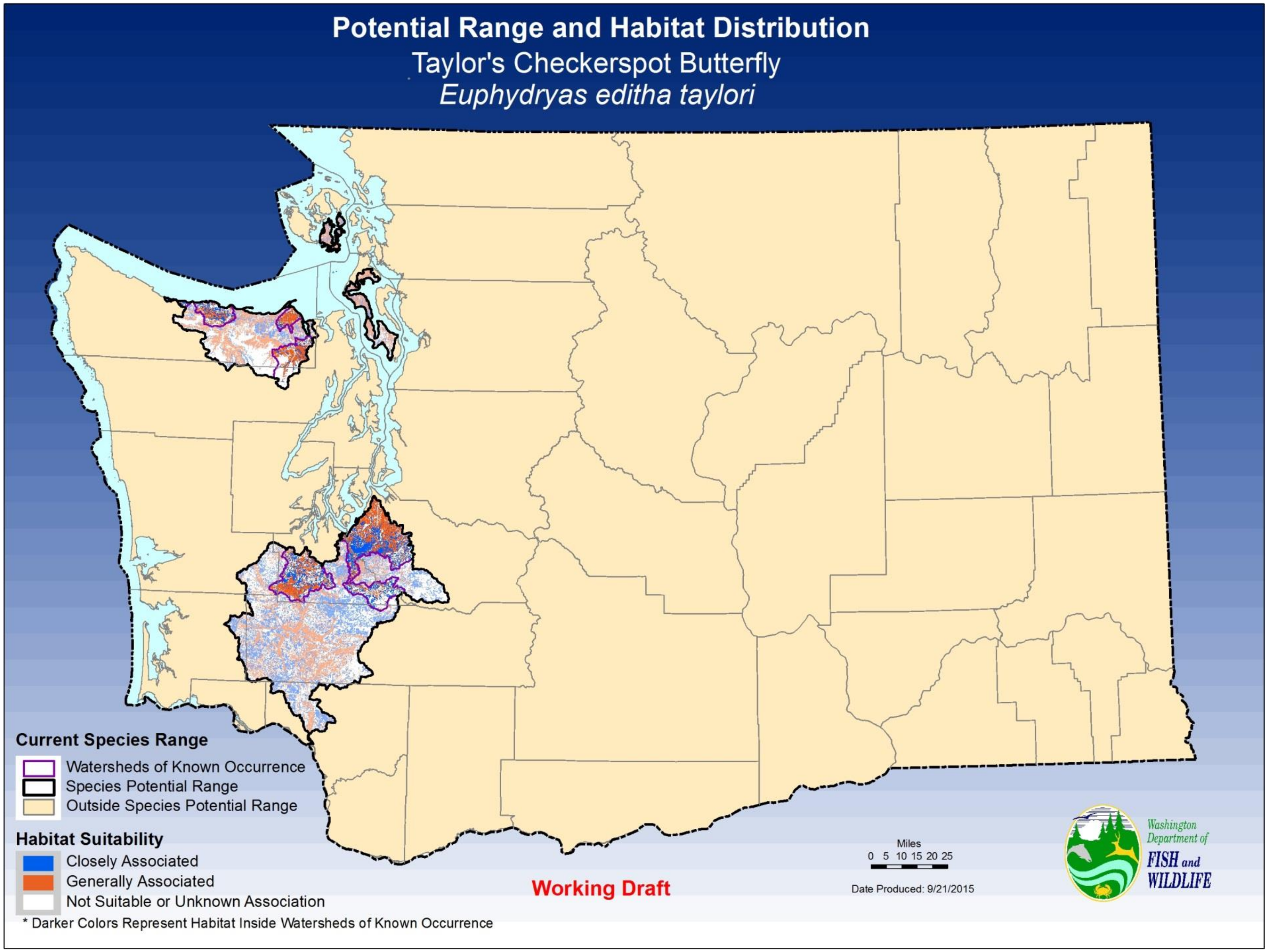
Mardon Skipper



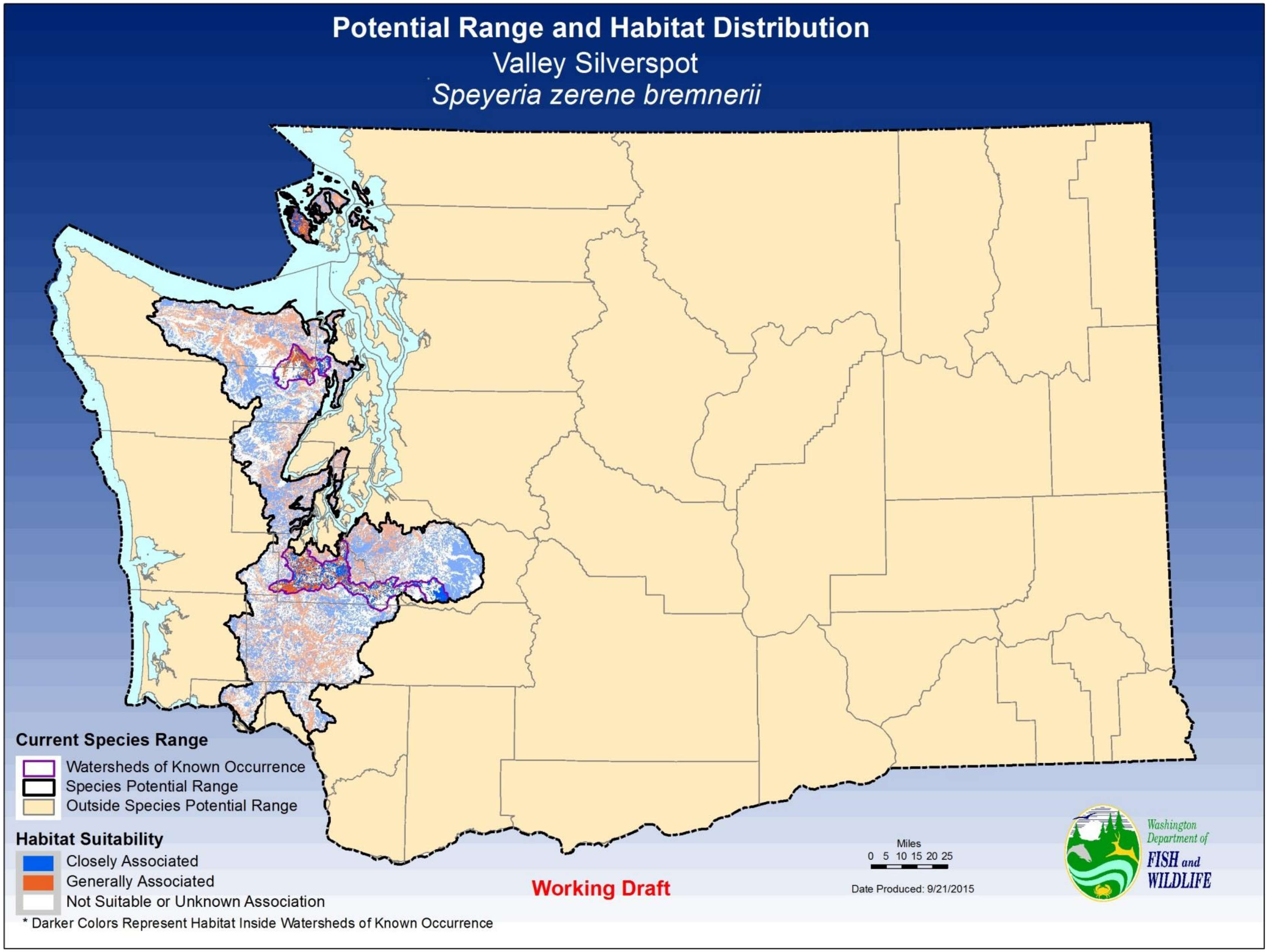
Oregon Silverspot



Taylor's Checkerspot Butterfly



Valley Silverspot



Appendix C

Climate Change: Supporting Information

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Appendix C
Climate Change: Supporting Information

C.0 Introduction and Overview

This appendix contains background materials and additional information to support the summary of climate impacts and species and habitat vulnerability presented in Chapter 5. Two major items are included here: 1) a full summary of projected climate change in Washington State in a 30-50 year time frame, with a focus on how these changes will impact fish and wildlife species and their habitats, and 2) a complete list of the vulnerability rankings for all SGCN and Ecological systems of concern, with narrative explanations and references. A complete list of references is provided at the end of the appendix.

C.1 Summary of Projected Climate Change in Washington State

Climate in the Pacific Northwest has been changing significantly over the past century as a result of natural climate variability and greenhouse gas emissions, resulting in warmer air temperatures and variable precipitation patterns. Air temperatures are projected to continue increasing over the next century, while precipitation will remain variable but largely exhibit summer declines, leading to a future with significantly altered snowpack, streamflow patterns, water availability, wildfire risk, ocean pH, and sea levels. These changes will have various impacts on terrestrial, aquatic, and marine and coastal habitats and their associated species in Washington State, potentially contributing to range and phenological shifts, biodiversity threats, habitat degradation, species displacement, changes in important stressors (e.g., invasive species, disease), and other impacts.

This overview outlines priority climate change factors and impacts to consider for the Pacific Northwest, general anticipated changes amongst the various habitat types of Washington State, and the potential effects on Washington's fish, wildlife, and plant species. A table summarizing observed and projected changes can be found at the end of this narrative overview (Table C-9). Although this overview provides projections based on the most current available information, it is important to note that future greenhouse gas emissions will play a large role in determining the magnitude of projected changes. For example, emissions from the first years of the 21st century were higher than predicted by most climate models.[1] In addition, climate shifts and associated impacts may be exacerbated or ameliorated by human activities and responses (e.g., habitat destruction vs. restoration treatments).

C.1.1 Climate Impacts of Concern

Air Temperature

Average annual air temperatures in the Pacific Northwest have been increasing over the past century, including increases in all seasons and in both maximum and minimum air temperatures (Table C-9). Temperatures are projected to continue increasing in all seasons through the end of this century (Table C-9) at rates between 0.1-0.6°C (0.2-1.0°F) per decade and exceeding the previous century's historic ranges of year-to-year variability. Summer temperatures are projected to warm more rapidly than

[1] Raupach, M. R., Marland, G., Ciais, P., Le Quéré, C., Canadell, J. G., Klepper, G., & Field, C. B. (2007). Global and regional drivers of accelerating CO_2 emissions. *Proceedings of the National Academy of Sciences, 104*(24), 10288-10293.

winter temperatures' and the interior of Washington State is projected to experience slightly greater warming than coastal areas. In addition, the number, mean duration, and maximum duration of extreme heat events are expected to increase, particularly in south central Washington and lowlands in western Washington.

Secondary impacts:[2] Temperature increases have already caused significant changes in other environmental variables, and will likely continue to alter these factors in the future (Table C-1).

Table C-1: Observed and projected trends of secondary impacts caused by warming temperatures

Secondary Impact	Observed Change	Projected Change
Reduced snowpack	Snowpack declined significantly (average 25%) during the latter half of the 20th century, and although there have been recent increases this is likely due to natural variability.	April 1st snowpack is projected to continue decreasing significantly throughout this century (-53% to -65% by 2080) as warmer temperatures drive shifts from snow to rain. Snowpack losses will be greatest at lower elevations and more modest at higher elevation.
Earlier snowmelt	Snowmelt occurred 0-30 days earlier (depending on location) in the Cascade Mountains during the latter half of the 20th century.	Snowmelt is projected to occur increasingly earlier by 2050, potentially three-four weeks earlier than 20th century average.
Drought risk	The PNW has experienced several droughts over the last decade, some which are attributed to warmer temperatures, reduced water storage in snowpack, and elevated evaporation and evapotranspiration.[3]	Enhanced drought stress as warmer temperatures drive increased evapotranspiration and reduced snowpack storage.
Hydrological shifts	Over the past half-century, snow-dominated watersheds have experienced earlier snowmelt runoff and reduced snowmelt contributions. All watersheds are experiencing reduced summer flows.	Future hydrological responses will largely vary by basin type (Table C-3), relative influence of groundwater input, elevation, aspect, and other factors. Warmer temperatures will likely drive shifts from snow-dominant to transient or rain-dominant basins (Figure C-1), and streamflow timing will likely occur earlier in snow-dominant and transient basins.

[2] Includes observed and projected physical, ecological, and biological changes.
[3] Bumbaco, K. A., & Mote, P. W. (2010). Three recent flavors of drought in the Pacific Northwest. *Journal of Applied Meteorology and Climatology, 49*(9), 2058-2068.

Secondary Impact	Observed Change	Projected Change
Flood risk and erosion	20th century warming caused no change in flood risk for rain-dominant basins, reduced flood risk in snow-dominant basins (due to reduced snowpack), and highly variable but generally elevated flood risk in transient basins.[4]	Increasing flood risk and erosion in transient basins. Snowmelt and rain-dominant basins will see minimal or slight increases (Table C-3).
Soil moisture changes	Spring soil moisture recharge has been occurring earlier in the Pacific Northwest over the past half century (1943-2003). Over the same time period, July 1 soil moisture trends have been variable, and warmer areas (e.g., the Washington coast) have experienced declines.	July 1 soil moisture is largely projected to decline across Washington State (-15 to -18% by 2080) although directions and rates of change vary depending on location. For example, areas west of the Cascades are projected to experience decreased soil moisture.
Wildfire risk	Warmer temperatures have contributed to increasing wildfire frequency and extent in the Pacific Northwest since the 1970s.	Increased lightning activity and projected temperature increases will contribute to increased fire frequency, severity, intensity, and total area burned in the Pacific Northwest, although the magnitude of change will likely vary by eco-region and suppression efforts. Forested ecosystems are projected to experience a larger relative increase in area burned than non-forested, and western forests will likely experience larger increases in burn area and severity than eastern forests or forests of the Columbia Plateau.
Insect and disease risk	Warmer temperatures have contributed to more mountain pine beetle outbreaks and elevated disease exposure, increasing tree mortality.	Insects: range expansions upward in elevation, earlier arrival or emergence, and accelerated reproductive cycles. Disease: increased disease incidence.
Range shifts	Tree seedlings have already exhibited shifts to cooler locations than parent trees.[5]	Continued northward or higher elevation shifts in species distributions.

[4] Hamlet, A. F., & Lettenmaier, D. P. (2007). Effects of 20th century warming and climate variability on flood risk in the western US. *Water Resources Research, 43*(6).
[5] Monleon, V. J., & Lintz, H. E. (2015). Evidence of tree species' range shifts in a complex landscape. *PloS One, 10*(1), e0118069.

Secondary Impact	Observed Change	Projected Change
Pheno-logical shifts	Phenological changes have already been observed, including earlier flowering and leaf unfolding.	Continued shifts in phenological timing (e.g., earlier migration, earlier algal blooms, earlier plant bloom/senescence), which can affect habitat quality and/or desynchronize life history traits with key environmental conditions (e.g., outmigration of salmon and oceanic prey availability).

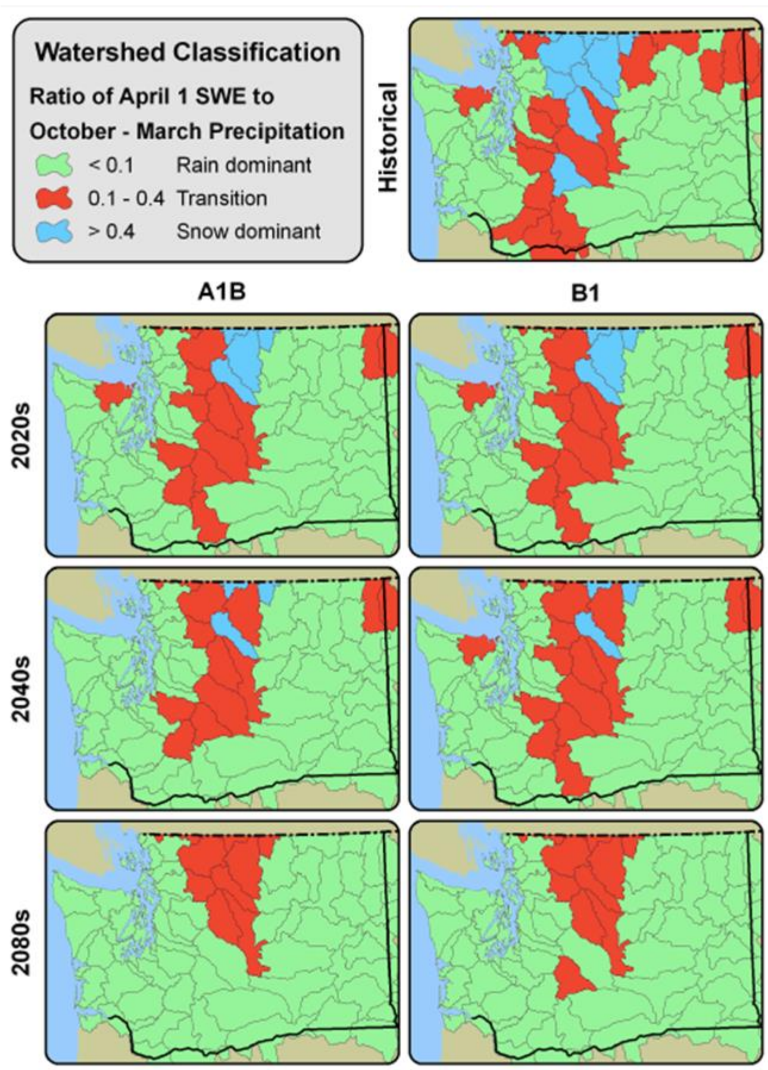

Figure C-1: Watershed Classification Maps

Watershed Classification Maps[6] for simulated runoff in the historic period (1970-99), 2020s, 2040s,

[6] Image from page 234 of Washington Climate Impacts Group. (2009). The Washington Climate Change Impacts Assessment, M. McGuire Elsner, J. Littell, and L. Whitely Binder (eds). Center for Science in the Earth System, Joint Institute for the Study of the Atmosphere and Oceans, University of Washington, Seattle, Washington.

and 2080s in Washington State. Simulations using A1B emissions are in the lower three rows of the left column, while those using B1 emissions scenarios are in the lower three rows of the right column.

Examples of impacts of changes in air temperature on habitats and species

- Declines in certain vegetation types (e.g., pine forests, Douglas fir, subalpine forests, sagebrush steppe) and expansions in others (e.g., prairie) as suitable habitat ranges shift, driving alterations in wildlife habitat availability and species distributions.
- Changes in productivity amongst many vegetation types (e.g., increases in higher elevation forests due to lengthened growing season, decreases in lower elevation forests due to heat and moisture stress).
- Shifts in phenology, affecting plant reproduction and/or productivity and animal life histories, survival, reproduction, and growth.
- Increases in wildfire frequency due to reduced fuel moisture, affecting plant survival and composition and forest-dependent wildlife species.
- Altered flow regimes (e.g., low summer flows), affecting salmon and steelhead migration, reproductive success, and habitat availability.
- Increases in forest disease risk and mortality due to exacerbated moisture stress.
- Changes in the frequency and severity of flood risk, affecting riparian vegetation community composition and structure.
- Increases in mountain pine beetle vulnerability (short-term) as beetles shift upward in elevation and trees experience increased moisture stress, with declines in vulnerability (long-term) as temperatures exceed insect thermal tolerance.
- Alterations in invasive species pressure; some species may expand, while some may decline.

Precipitation

Separated by the Cascade Mountains, eastern and western Washington feature distinct precipitation regimes, with western zones receiving significantly more rainfall than eastern zones. There has been no significant trend in precipitation over the past century (Table C-9), as this region experiences high natural variability. Precipitation projections are highly variable, and may include either increases or decreases in annual precipitation over the next century (Table C-9); these changes are small when compared to ranges of natural variability in the Pacific Northwest. There is higher certainty regarding seasonal precipitation trends; by the end of the century, winters will likely be wetter and summers will likely be drier. Precipitation intensity may also increase, particularly in the North Cascades and northeastern Washington.

Secondary impacts:[7] Shifts in precipitation timing, amount, and form have caused significant changes in other environmental variables, and will likely continue to alter these factors in the future (Table C-2).

[7] Includes observed and projected physical, ecological, and biological changes.

Table C-2: Observed and projected changes of secondary impacts caused by precipitation changes

Secondary Impact	Observed Change	Projected Change
Snowpack changes	Snowpack declined significantly (average -25%) during the latter half of the 20th century.	High elevation areas may potentially experience increased snowfall as a result of increasing winter precipitation. Basins with low elevation snow may experiences snowpack declines as more precipitation falls as rain.
Hydrological shifts	Declining summer streamflows have been recorded in all basin types since 1950.	*Streamflow*: winter streamflows will likely increase in all basins, while summer flows will likely decrease as a result of reduced summer precipitation and shifts in snowpack. *Runoff*: mean annual runoff is projected to increase over the course of the century due to increased winter precipitation, with winter streamflow increases and summer streamflow decreases. Individual stream response will largely depend on basin classification (Table C-3), elevation, aspect, and groundwater influx, among other factors
Flood risk and erosion	Variability in 20th century cool season precipitation increased flood risk in rain-dominant and transient basins.	Increases in extreme precipitation and winter precipitation could increase flood risk and erosion significantly in transient basins, with slight increases possible rain-dominant basins (Table C-3).
Drought risk	The Pacific Northwest has experienced several droughts over the last decade, some of which are attributed to reduced winter and/or summer precipitation.[8]	Declines in summer precipitation will likely exacerbate drought stress caused by increasing temperatures and evapotranspiration.

[8] Bumbaco, K. A., & Mote, P. W. (2010). Three recent flavors of drought in the Pacific Northwest. *Journal of Applied Meteorology and Climatology, 49*(9), 2058-2068.

Secondary Impact	Observed Change	Projected Change
Soil moisture changes	July 1 soil moisture trends have been variable from 1943-2003, and warmer areas (e.g., the Washington coast) have experienced declines.	July 1 soil moisture is largely projected to decline across Washington State (-15 to -18% by 2080) although directions and rates of change vary depending on location. For example, areas west of the Cascades are projected to experience decreased soil moisture, while some areas east of the Cascades will experience soil moisture increases as increased winter precipitation/snowpack at the highest elevations recharges moisture in deep soil horizons.
Wildfire risk	Drier conditions have contributed to increasing wildfire frequency and extent in the Pacific Northwest since the 1970s.	Precipitation variability (particularly drier summers) and water-deficit increases over the next century will likely contribute to increasing fire frequency, severity, intensity, and total area burned in the Pacific Northwest, although the magnitude of change will likely vary by eco-region, vegetation type, and suppression effort.
Insect and disease risk	Moisture stress has contributed to higher forest vulnerability and mortality from insects and disease.	Insect and disease risk will likely increase with drier conditions.

Table C-3: Historic behavior and future projected responses of various watershed types in Washington State

Modified from Elsner et al. (2009, pgs. 70, 92) and Climate Impacts Group (2012, pg. 5)

Watershed classification	Historic characteristics	Future projected responses
Rain dominant	• Peak streamflow in winter with peak precipitation (November-January) • Low summer streamflow	• Slightly increased winter streamflows and flood risk • Decreased summer low flows
Snowmelt dominant	• Peak streamflow with spring/early summer snowmelt (May-July) • Low winter streamflow	• Slightly increased winter and spring streamflows • Minimal shifts in flood risk • Earlier and reduced summer peak and low flows • May transition to transient classification
Transient	• Two streamflow peaks, one with peak precipitation (winter) and one with snowmelt (spring/early summer)	• Larger and more consistent winter streamflows • Increased flood risk • Earlier and reduced and/or loss of snowmelt-associated summer streamflows, decreased low flows • May transition to rain dominant classification

Examples of impacts of changes in precipitation on habitats and species

- Shifts in soil moisture and nutrient and energy fluxes may contribute to changes in habitat distributions (e.g., declines in pine forests, Douglas fir, subalpine forests, sagebrush steppe due to moisture stress; prairie expansions due to tolerance of xeric conditions), driving shifts in wildlife habitat availability and species distributions.
- Shifts in vegetation productivity (e.g., moisture and nutrient deficits can undermine productivity).
- Increased nutrient loss due to increasing extreme precipitation events and elevated runoff.
- Decreased fuel moisture content may increase wildfire risk, affecting vegetation distribution and composition and forest-dependent wildlife species.
- Reduced annual low flows may increase aquatic organism vulnerability to water pollution and heat stress, and affect salmon and steelhead migration and reproductive success.
- Changes in frequency and severity of flood risk, affecting riparian vegetation community composition and structure, fish habitat (e.g., bull trout), and aquatic organism exposure to water pollution (e.g., sediments, pathogens, and pollutants).
- Increases in mountain pine beetle vulnerability and forest disease susceptibility due to moisture stress.

Water Temperature

Freshwater temperature

Stream temperatures in the northwest United States experienced a net increase from 1980-2009 largely as a result of increasing air temperatures, with rates of summer warming of 0.22°C per decade.[9] Spring and summer stream temperatures are projected to continue increasing across the state,[10,11] including increases in the frequency and duration of unfavorable temperature events (periods with water temperatures >21°C). These trends will be particularly pronounced in eastern Washington (Yakima River), the Columba River (near Bonneville Dam), the Lower Snake River, and in western Washington (Stillaguamish River, Lake Washington, Lake Union). Similar to streamflow, stream temperature changes will vary according to location, groundwater input, topography, and other factors.

Secondary impacts:[12] Shifts in freshwater temperature have caused significant changes in other environmental variables, and will likely continue to alter these factors in the future (Table C-4).

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[9] Isaak, D. J., Wollrab, S., Horan, D., & Chandler, G. (2012). Climate change effects on stream and river temperatures across the northwest U.S. from 1980–2009 and implications for salmonid fishes. *Climatic Change, 113*(2), 499-524.
[10] Beer, W., & Anderson, J. (2011). Sensitivity of juvenile salmonid growth to future climate trends. *River Research and Applications, 27*(5), 663-669.
[11] Mantua, N., Tohver, I., & Hamlet, A. (2010). Climate change impacts on streamflow extremes and summertime stream temperature and their possible consequences for freshwater salmon habitat in Washington State. *Climatic Change, 102*(1-2), 187-223.
[12] Includes observed and projected physical, ecological, and biological changes.

Table C-4: Observed and projected changes of secondary impacts caused by warming freshwater temperatures

Secondary Impact	Observed Change	Projected Change
Stratification and hypoxia	Lake and reservoir stratification is occurring earlier as a result of warmer water temperatures, extending the length of summer stratification. Stratification causes lower dissolved oxygen levels and stresses aquatic species.[13]	Enhanced spring/summer lake stratification, reduced primary productivity, and reduced oxygen solubility, contributing to increasing incidence of hypoxia.
Algal blooms	Longer algal growing seasons observed with warmer temperatures.	Increased likelihood of lake algal blooms.
Range shifts	Bull trout have exhibited range contractions to higher, cooler refugia in the Rocky Mountains in response to warmer temperatures.[14]	Cool- and cold-water habitats will likely shift further upstream. The range of warm-adapted aquatic invaders will likely expand.
Phenological shifts	Fish migration (e.g., lamprey) has been documented to occur earlier in years with warmer and lower streamflow. Predator-prey mismatch has caused mortality and population declines of some freshwater species.	Continued or exacerbated behavioral changes, affecting migration, spawning timing, and/or foraging success and survival.

Examples of impacts of warmer water temperatures on habitats and species

- Declines in suitable aquatic habitat and prey availability, and exceed fish thermal limits, contributing to increased fish kills, undermined fish health (e.g., enhanced disease susceptibility), altered reproductive success, and/or inhibited migration.
- Upstream shift in suitable stream habitat for many aquatic species, potentially reducing overall habitat availability. These shifts will be largest in flat rivers and smallest in steeper streams, and most pronounced in transient river basins.
- Enhanced vulnerability to aquatic invasive species, which can displace, compete with, or prey upon native aquatic biota.
- Increased fish metabolic and growth rates provided enough food and oxygen is available.

[13] Mantua, N., Tohver, I., & Hamlet, A. (2009). Impacts of climate change on key aspects of freshwater salmon habitat in Washington State. *Washington Climate Change Impacts Assessment: Evaluating Washington's future in a changing climate. Climate Impacts Group, University of Washington, Seattle, Washington*.

[14] Eby, L. A., Helmy, O., Holsinger, L. M., & Young, M. K. (2014). Evidence of climate-induced range contractions in Bull Trout Salvelinus confluentus in a Rocky Mountain watershed, USA. *PloS one, 9*(6), e98812.

Ocean temperature

Global sea surface temperatures have increased 0.6°C (1.1°F) since 1950, but no significant ocean warming offshore of North America was observed between 1900-2008, except in localized areas (e.g., west of Vancouver Island). However, northwest ocean temperatures are projected to increase 1.22°C (2.2°F) by the 2040s. Projections for coastal ocean temperatures are less clear due to high natural variability and upwelling influence.

Secondary impacts:[15] Shifts in ocean temperature have caused significant changes in other environmental variables, and will likely continue to alter these factors in the future (Table 5).

Table C-5: Observed and projected changes of secondary impacts caused by warming ocean temperatures

Secondary Impact	Observed Change	Projected Change
Stratification and altered ocean circulation	Increased stratification, reducing vertical mixing and affecting primary productivity.	Further stratification and altered ocean mixing, affecting primary productivity. Shifts in upwelling also expected as temperatures gradients between land and sea change.
Algal blooms	Highest bloom activity with warmer water temperatures in Puget Sound.[16] Prolonged growth. season and enhanced competitive advantage for dinoflagellate algal blooms, increasing bloom duration and toxicity.[17]	More frequent, earlier and longer algal blooms.[18]
Lower dissolved oxygen	Reduced oxygen delivery to deeper waters.	Decreased oxygen levels in the open ocean and coastal waters.
Reduced primary productivity	Reductions in primary productivity, expansion in surface water area with low phytoplankton biomass.	Potential reductions in primary productivity, leading to hypoxic conditions and marine food web alterations.

[15] Includes observed and projected physical, ecological, and biological changes.

[16] Moore, S. K., Mantua, N. J., Hickey, B. M., & Trainer, V. L. (2009). Recent trends in paralytic shellfish toxins in Puget Sound, relationships to climate, and capacity for prediction of toxic events. *Harmful Algae, 8*(3), 463-477.

[17] Moore, S. K., Trainer, V. L., Mantua, N. J., Parker, M. S., Laws, E. A., Backer, L. C., & Fleming, L. E. (2008). Impacts of climate variability and future climate change on harmful algal blooms and human health. *Environmental Health, 7*(2), S4.

Examples of impacts of changes in ocean temperature on habitats and species

- Altered abundance, distribution, and composition of marine and coastal species (e.g., reduced salmon and squid abundance, northward shift of sardines).
- Altered prey availability (e.g., reduced surface prey for foraging seabirds).
- Phenological shifts, including developmental changes, age to sexual maturity, growth, and spawning changes.
- Enhanced disease risk and invasive species spread.

Sea Level

Global sea levels rose 1.8 (+/- 5) mm/yr between 1961-2003, with rates accelerating to 3.1 (+/- 0.7) mm/yr in the last decade of observation. In the Pacific Northwest, sea levels are largely increasing, although some areas are experiencing decreases. Rates of sea level rise are projected to continue increasing globally over the next century,[18] and Washington State could experience increases of +4 to +56 inches by 2100 (relative to 2000). However, there will be high local variability caused by vertical land deformation (i.e., uplift and subsidence), seasonal ocean elevation change (i.e., wind-enhanced sea level rise during winters and El Niño events), and other factors (e.g., groundwater withdrawal). For example, Puget Sound is projected to keep pace with global sea level rise and experience the most sea level rise by the end of the century (Table 2). The northwest Olympic Peninsula, which is experiencing significant uplift (>2 mm/yr), will see much lower increases and/or declines in sea level by 2100. The central and southern coasts, which may be experiencing moderate uplift (0-2 mm/yr), will likely experience sea level increases with magnitudes in between the other two regions during the same time period. Across the state, these general trends will fluctuate depending on changes in atmospheric circulation and wind patterns, short- and long-term land deformation events, and ice loss rates in Greenland and Antarctica. For example, sea levels can fluctuate up to 12 inches according to the El Niño Southern Oscillation or the Pacific Decadal Oscillation.

Secondary impacts:[19] Shifts in sea level have caused significant changes in other environmental variables, and will likely continue to alter these factors in the future (Table 6).

Table C-6: Observed and projected changes of secondary impacts caused by warming freshwater temperatures

Secondary Impact	Observed Change	Projected Change
Shoreline erosion/loss	Erosion rate varies by location.	Higher sea levels will generally increase erosion and/or expose new areas to erosion, contributing to shoreline loss and forced inland migration of coastal habitats.
Saltwater intrusion	Aquifer saltwater intrusion already occurring in some	More frequent saltwater intrusion into coastal aquifers and wetlands may

[18] Projected rates of global sea level rise vary, but many studies project that global sea levels will rise somewhere between 2-4 ft during the 21st century.
[19] Includes observed and projected physical, ecological, and biological changes.

	locations (e.g., Whidbey Island).[20]	compromise water quality and force habitat conversion to more salt-tolerant species.
Storm surge	Increased beach erosion with winter storms and larger wave heights.	Higher sea levels could allow storm surges to reach new areas, causing more frequent inundation and erosion.

Examples of impacts of sea level rise on habitats and species

- Shifts in coastal habitat extent and quality as a result of increased inundation and erosion (e.g., beaches, tidal flats, coastal wetlands may decline, marshes may expand).
- Habitat or breeding ground loss for some species (e.g., shorebirds), habitat increases for other species (e.g., marsh associates).
- Shifts in species composition and biodiversity in coastal habitats, as well as shifts in species interactions.
- Larger marine food webs may be affected if important food species or habitat (e.g., estuarine nursery) is lost.
- Increases in salinity associated with sea level rise may facilitate invasive species spread in estuaries and/or stress freshwater coastal species.

Water Chemistry

Oxygen

The coastal waters of Washington State have been experiencing seasonal hypoxic conditions since at least 1950,[21] and feature the lowest recorded dissolved oxygen (DO) levels of the California Current System.[22] Hypoxic conditions are most common during the upwelling season (May-October), with DO levels fluctuating according to the DO content of upwelled waters, runoff nutrient input, and primary productivity.[19] Coastal hypoxia episodes may increase as a result of climate change due to warmer sea surface temperatures, which affect oxygen solubility, and intensified upwelling as a result of shifting wind patterns.[23]

Secondary impacts:[24] Shifts in oxygen availability have caused significant changes in other environmental variables, and will likely continue to alter these factors in the future (Table 7).

[20] Huppert, D. D., Moore, A., & Dyson, K. (2009). Impacts of climate change on the coasts of Washington State. *Washington Climate Change Impacts Assessment: Evaluating Washington's Future in a Changing Climate*, 285-309.

[21] Connolly, T., Hickey, B., Geier, S., & Cochlan, W. (2010). Processes influencing seasonal hypoxia in the northern California Current System. *Journal of Geophysical Research: Oceans (1978–2012), 115*(C3).

[22] Peterson, J. O., Morgan, C. A., Peterson, W. T., & Lorenzo, E. D. (2013). Seasonal and interannual variation in the extent of hypoxia in the northern California Current from 1998–2012. *Limnology and Oceanography, 58*(6), 2279-2292.

[23] Morgan, E., & Siemann, D. (2010). Climate Change Effects on Marine and Coastal Habitats in Washington State *Prepared for the Ecosystems, Species, and Habitats Topic Advisory Group*. Available at: http://dfwwbolyhq01.dfw.wa.gov/conservation/climate_change/publications/marine_coastal_climate_science_summary.pdf

[24] Includes observed and projected physical, ecological, and biological changes.

Table C-7: Observed and projected changes of secondary impacts caused by warming freshwater temperatures

Secondary Impact	Observed Change	Projected Change
Dead zones	Increasing frequency and prevalence of hypoxic dead zones in coastal areas since 1960.[25]	More frequent and persistent low oxygen conditions due to warming and elevated stratification, with potential expansion into shallower waters. This is especially a concern in Hood Canal.

Examples of impacts of changes in oxygen on habitats and species

- Altered aquatic organism behavior, health, growth, reproductive success, and survival.
- Altered aquatic organism distribution and composition; sessile organisms may be less able to migrate in response to changing hypoxic conditions.
- Impaired biological, ecological, and biogeochemical processes.
- Altered prey availability.
- Reduced oxygen availability due to increased algal blooms, further contributing to hypoxic conditions.
- Increased sensitivity to pollutants and contaminants.

Acidity (pH)

Global ocean surface pH has declined 0.1 units since 1750, with rates of -0.02 units/yr in the past two decades.[26] Since 1800, outer coastal water acidity in Washington State has increased 10-40%, translating to a pH decline of -0.05 to -0.15. Global ocean surface pH, as well as pH in the North Pacific, is projected to decline an additional -0.2 to -0.3 units by 2100, translating to a 100-150% increase in ocean acidity.[27]

Secondary impacts:[28] Shifts in acidity have caused significant changes in other environmental variables, and will likely continue to alter these factors in the future (Table 8).

Table C-8: Observed and projected changes of secondary impacts caused by changes in pH

Secondary Impact	Observed Change	Projected Change
Dead zones	Increasing frequency and prevalence of hypoxic dead	pH decreases will contribute to the formation of dead zones.

[25] Diaz, R. J., & Rosenberg, R. (2008). Spreading dead zones and consequences for marine ecosystems. *Science, 321*(5891), 926-929.

[26] Feely, R. A., Doney, S. C., & Cooley, S. R. (2009). Ocean acidification: present conditions and future changes in a high-CO2 world. *Oceanography, 22*(4), 37-47.

[27] Feely, R. A., Alin, S. R., Newton, J., Sabine, C. L., Warner, M., Devol, A., . . . Maloy, C. (2010). The combined effects of ocean acidification, mixing, and respiration on pH and carbonate saturation in an urbanized estuary. *Estuarine, Coastal and Shelf Science, 88*(4), 442-449.

[28] Includes observed and projected physical, ecological, and biological changes.

	zones in coastal areas since 1960;[29] exacerbates and exacerbated by acidification.[30]	
Algal blooms	Increased growth and/or toxicity of algal blooms observed in more acidic waters.[31]	Increased acidity may contribute to more algal blooms.[32]
Nutrient and metal solubility	Lowered calcium-carbonate saturation states.	pH can change the quantity of available nutrients; too many nutrients may cause plant overgrowth and as the plants decompose, dissolved oxygen levels lower even further. More acidic water typically increases the solubility of heavy metals, making these metals more toxic to species.

Examples of impacts of changes in pH on habitats and species

- Reduced shellfish populations due to calcium carbonate declines.
- Reduced ability for plankton to form calcium carbonate shells, significantly affecting marine food webs and the survival, growth, and reproductive capacity of fish populations.
- Increased growth rates of seagrass.
- Increased risk of invasive species establishment.

[29] Diaz, R. J., & Rosenberg, R. (2008). Spreading dead zones and consequences for marine ecosystems. *Science, 321*(5891), 926-929.

[30] Cai, W.-J., Hu, X., Huang, W.-J., Murrell, M. C., Lehrter, J. C., Lohrenz, S. E., . . . Wang, Y. (2011). Acidification of subsurface coastal waters enhanced by eutrophication. *Nature Geoscience, 4*(11), 766-770. Cai, W.-J., Hu, X., Huang, W.-J., Murrell, M. C., Lehrter, J. C., Lohrenz, S. E., . . . Wang, Y. (2011). Acidification of subsurface coastal waters enhanced by eutrophication. *Nature Geoscience, 4*(11), 766-770.

[31] Moore, S. K., Mantua, N. J., Hickey, B. M., & Trainer, V. L. (2009). Recent trends in paralytic shellfish toxins in Puget Sound, relationships to climate, and capacity for prediction of toxic events. *Harmful Algae, 8*(3), 463-477.

Table C-9: Summary of key climate factors, trends, observed and projected changes, and compounding factors in Washington State

Climate Factor	General Trend	Observed Changes	Projected Changes	Compounding Factors*********
Air temperature	Increasing	+0.13°F/decade (1895-2011) Pacific Northwest (1920-2000): • Annual: +0.91°C (1.64°F) • Summer: +1.07°C (1.93°F) • Winter: +1.83°C (3.3°F) • Spring: +0.57°C (1.03°F) • Fall: +0.18°C (0.32°F)	Increases, with warming most severe in summer Pacific Northwest (relative to 1970-99): 2020s • Annual: +1.1°C (2.0°F) • Summer: +1.3-1.7°C (2.3-3.1°F) • Winter: +1.1-1.2°C (2.0-2.2°F) • Spring: +1.0°C (1.8°F) • Fall: +1.0-1.1°C (1.8-2.0°F) 2040s • Annual: +0.91°C (1.64°F) • Summer: +1.9-2.7°C (3.4-4.9°F) • Winter: +1.6-1.9°C (2.9-3.4°F) • Spring: +1.4-1.7°C (2.5-3.1°F) • Fall: +1.5-2.0°C (2.7-3.6°F) 2080s • Annual: +3.0°C (5.3°F) • Summer: +3.0-4.5°C (5.4-8.1°F) • Winter: +2.7-3.3°C (4.9-5.9°F) • Spring: +2.1-2.8°C (3.8-5.0°F) • Fall: +2.4-3.4°C (4.3-6.1°F)	• Natural climatic patterns, such as the El Niño-Southern Oscillation (ENSO) and Pacific Decadal Oscillation (PDO) • Increasing electrical demand for cooling and water demand for irrigation • Human development
Precipitation	Variable	No significant trend	Annual precipitation will be variable, but there will be declines in summer precipitation Pacific Northwest (relative to 1970-99) 2020s • Annual: +1% (-9 to +12%) • Winter: +2% (-14 to +23%)	• ENSO/PDO • Increasing electrical demand for cooling and water demand for irrigation

********* Compounding factors or synergistic effects that may exacerbate or ameliorate the effects of climate change on habitats and species.

Climate Factor	General Trend	Observed Changes	Projected Changes	Compounding Factors*********
			• Summer: -6% (-30 to +12%) 2040s • Annual: +2% (-11 to +12%) • Winter: +3% (-13 to +27%) • Summer: -8% (-30 to +17%) 2080s • Annual: +4% (-10 to +20%) • Winter: +8% (-11 to +42%) • Summer: -13% (-38% to +14%)	
Snowpack	↓	Pacific Northwest: Significant declines (average -25%) during latter half of 20th century. Recent increases likely due to natural variability.	Further declines (-53% to -65% by 2080). Snowpack losses will be greatest at lower elevations and more modest at higher elevations.	• ENSO/PDO
Snowmelt	Earlier	Cascade Mountains: occurred 0-30 days earlier (depending on location) during latter half of 20th century.	Will occur increasingly earlier by 2050.	• ENSO/PDO
Drought	increasing	Pacific Northwest: experienced several droughts since 2001. Droughts attributed to several causes including: warmer temperatures, reduced snowpack and earlier snowmelt, and reduced winter and/or summer precipitation.	Increasing across the state, particularly in summer, even with potential increases in winter precipitation.	• Water withdrawals • Changes in land use and land cover
Streamflow/runoff	Variable	Snow-dominant and transient basins: earlier snowmelt runoff, leading to lower summer base flows. Rain-dominant: variable depending on annual precipitation.	Earlier streamflow timing in snow-dominant and transient basins. Annual runoff is projected to increase slightly, with increases in winter streamflow and declines in summer streamflows. Potential shifts from snow-dominant to transient or rain-dominant basins.	• ENSO/PDO • Groundwater and soil moisture influence • Topography • Adjacent land use • Water resources

Climate Factor	General Trend	Observed Changes	Projected Changes	Compounding Factors*********
				infrastructure •
Wildfire risk	increasing	Wildfire frequency and extent have been increasing in the Pacific Northwest since the 1970s.	Increased fire frequency, severity, intensity, and total area burned. Magnitude of change will likely vary by eco-region, vegetation type, and suppression effort.	• ENSO/PDO • Fire suppression • Drought stress • Invasive species and disease compromising tree/vegetation health
Freshwater temperature	↑	Net increase from 1980-2009; summer warming rate increased 0.22°C per decade	Increasing across the state, including increases in frequency and duration of unfavorable temperature events (periods with water temperatures >21°C)	• Low streamflows (caused by climate and/or water withdrawals) • Water resources infrastructure (e.g., dams) • Changes in land use and land cover
Ocean temperature	↑	Global: increased 0.6°C (1.1°F) since 1950 North America: no significant trends (1900-2008); some warming in localized areas (e.g., west of Vancouver Island)	Northwest ocean temperatures to increase 1.22°C (2.2°F) by the 2040s	• ENSO/PDO • Changes in land use and land cover
Sea level	↑, some areas ↓	Global: increased 1.8 (±0.5) mm/yr between 1961-2003; rates accelerated to 3.1 (±0.7) mm/yr from 1993-2001 Washington: • Friday Harbor: +0.4 in/decade • Neah Bay: -0.7 in/decade (1934-2008) • Seattle: +0.8 in/decade (1900-2008)	Continued increases, although some areas will experience decreases Washington: +4 to +56 in by 2100 - Northwest Olympic Peninsula: • 2050: 0 in (-5 to +14 in) • 2100: +2 in (-9 to +35 in) - Central & Southern Coast • 2050: +5 in (+1 to +18 in) • 2100: +11 in (+2 to +43 in) - Puget Sound • 2050: +6 in (+3 to +22 in)	• Habitat degradation of existing coastal habitat via dredging, development, pollution, and coastal modifications • Sediment supply changes • Development and natural barriers • Land subsidence • Storm wave heights • ENSO/PDO

Climate Factor	General Trend	Observed Changes	Projected Changes	Compounding Factors*********
			• 2100: +13 in (+6 to +50 in)	
Oxygen concentrations	↓	Seasonal hypoxia since at least 1950 during upwelling periods (May-October)	Increase due to warmer sea surface temperatures/decreased oxygen solubility and intensified upwelling	• Nutrient runoff (e.g., nitrogen) • Freshwater input • Reduced upwelling • Stratification • Removal of vegetation
pH	↓	Ocean surface pH declined 0.1 units since 1750; outer coastal acidity increased 10-40%	Decrease an additional -0.2 to -0.3 units by 2100	• Nutrient inputs from runoff • Fishing pressure • Habitat destruction

C.2 SGCN Vulnerability Rankings

C.2.1 Mammal Vulnerability Rankings

MAMMALS						
Species	Overall Vulnerability	Overall Confidence	Sensitivity Rank	Exposure Rank	Summary of Exposure	Summary of Sensitivity
American Badger	Moderate	Low	Moderate	Moderate	> Increased temperatures > Changes in precipitation > Reduced soil moisture > Altered fire regimes > Increased invasive weeds	Overall, there is a lack of information about the sensitivity of the American Badger to climate change. In general, sensitivity of this species appears to be driven by prey and habitat specialization. It occurs in shrub-steppe, grassland, and semi-desert habitats, requires friable soils for burrows, and preys primarily on ground squirrels and pocket gophers. Warmer, drier conditions that harden soils may negatively affect the American Badger or its prey species' ability to burrow. Warmer and drier conditions may allow grassland expansion, creating more habitat for this species. However, warmer, drier conditions that lead to more frequent and hotter fires and/or encourage the growth of invasive weeds (e.g. cheatgrass) may degrade or alter natural habitat for this species. Altered fire regimes in the Columbia Basin will likely negatively impact some prey species such as ground squirrels.
American Pika	High	High	High	Moderate-High	> Increased temperatures > Reduced snowpack > Shifts from snow to rain	The American Pika displays high sensitivity because of its preferred habitat type and condition, very low reproductive rate, and limited dispersal ability. The American Pika requires a moderate amount of snowpack in order to provide insulation during the winter months; decreasing snowpack because of rising temperatures and shifting precipitation patterns with more rain than snow will negatively impact this species. American Pika have high energetic demands, partly because they do not hibernate; increasing temperatures and extreme heat events may affect this species' ability to forage during the day. In addition, climate change will likely alter the composition of vegetation in montane habitats; this shift may be to plant species less suited to the species' nutritional needs.
Bighorn Sheep	Moderate	High	Moderate	Moderate	> Increased temperatures > Reduced snowpack > Earlier snowmelt	Warmer temperatures may reinforce thermoregulatory behavior of Bighorn Sheep in order to minimize heat stress (e.g. foraging on northern and easterly slopes). Warmer temperatures, reduced snowpack and earlier snowmelt may increase foraging opportunities by extending the growing and foraging season and increasing the upper limits of plant growth (e.g. grass); increased foraging opportunities

MAMMALS						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
					> Altered fire regimes	could potentially increase lamb survival. However, reduced snowpack and earlier snowmelt may also increase predation risk by allowing earlier predator access to subalpine/alpine habitats and/or by increasing predator cover via tree encroachment. Fire may moderate tree encroachment, thereby maintaining forage habitat and reducing predator risk.
Black-tailed Jackrabbit	Moderate	Moderate	Moderate	Moderate	> Altered fire regimes > Changes in wind > Increased invasive weeds > Increased disease outbreaks	The Black-tailed Jackrabbit occupies habitats with a wide temperature range and minimal moisture levels (e.g. grassland, scrub, desert); they are highly capable of thermoregulating and conserving water. They are sensitive to disturbance regimes, such as fire and wind; widespread fires can remove vegetation that provides nesting and thermal cover and foraging species, while wind has been shown to affect this species feeding behavior. Increased invasive weeds (e.g. cheatgrass) have little to no forage value for this species and may contribute to increased fire, further eliminating important sagebrush habitat. Climate change may amplify effects of disease and parasites on this species.
Blue Whale	Low-Moderate	High	Low-Moderate	Moderate	> Increased ocean temperatures > Altered circulation and/or upwelling patterns > Declines in pH	Due to their migratory patterns and the wide range of ocean conditions they experience, Blue Whales are unlikely to have physiological sensitivity to climate-induced ocean changes (e.g. increased sea surface temperature, decreased pH). Their overall sensitivity will be higher due to potential changes in their primary prey, euphausiids. Blue Whales require large aggregations of euphausiids for optimal foraging, and euphausiid conditions are strongly linked with oceanographic variability. Cooler, upwelling waters support high primary production and thus euphausiid biomass, while warmer waters like those found during positive Pacific Decadal Oscillations cycles or strong El Niño lead to lower primary productivity and decreased euphausiid abundance. Therefore, increases in sea surface temperature or changes in ocean circulation, as well as declines in pH, could lead to declines in euphausiid abundance and limited prey availability for Blue Whales. Additionally, changes in peak primary productivity and euphausiid abundance could lead to alterations in Blue Whale migration timing.
Brush Prairie Pocket Gopher	Low-Moderate	Low	Low-Moderate	Low-Moderate	> Increased temperatures > Changes in	There is no information on the sensitivity of the Brush Prairie Pocket Gopher to climate change. There is some evidence that pocket gophers in general may be sensitive to changes in temperature and precipitation

MAMMALS						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
					precipitation > Reduced soil moisture	that affect soil moisture and hardness, which impacts pocket gopher digging activity (i.e. burrows include foraging tunnels and chambers for nesting and food caching).
Cascade Red Fox	High	High	High	Moderate-High	> Increased temperatures > Reduced snowpack > Altered fire regimes	The Cascade Red Fox is presumably adapted to colder climates, and is restricted to alpine and subalpine ecosystems and high elevation meadows. The overall sensitivity of this species to climate change is likely driven by their dependence on these colder, high elevation habitats. Warmer temperatures and reduced snowpack may negatively impact this species by further contracting suitable habitat ranges and/or facilitating movement of Coyotes (potential competitor and predator) into the range of Cascade Red Foxes. Altered fire regimes that degrade or eliminate alpine and subalpine habitat is also likely to negatively impact this species.
Columbian White-tailed Deer	Moderate	Moderate	Moderate	Moderate	> Increased flooding > Sea level rise > Increased extreme precipitation events > Increased disease outbreaks	Occupying riparian habitats, bottomlands, and tidelands, Columbian White-tailed Deer are vulnerable to periodic habitat loss and subsequent population declines due to flooding. Past flood events have caused significant population reductions, followed by slow recovery. Consistent or consecutive yearly flooding and inundation as a result of sea level rise and/or shifting storm frequencies and intensities could significantly threaten the persistence of various populations, potentially forcing migration to marginal habitat areas. However, current efforts to translocate deer and establish new populations along the lower Columbia River increases overall population resilience to flooding and inundation impacts. Sea level rise and shifts in precipitation that elevate groundwater tables may also affect available forage by extending the range of relatively unpalatable reed canary grass. Reduced habitat or forage quality as a result of climate change could also increase deer vulnerability to various diseases.
Destruction Island Shrew	Low-Moderate	Low	Moderate	Low-Moderate	> Reduced soil moisture > Increased extreme events	Limited information is available regarding the biology and ecology of Destruction Island Shrews and their potential response to climate change. This species is likely sensitive to climate-driven changes in prey availability (e.g. insects, spiders, worms, centipedes) and habitat suitability (e.g. vegetation cover). For example, soil moisture may affect burrowing and/or suitability and availability of grassland habitat. In addition, as this species is endemic to Destruction Island, it is likely

MAMMALS						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						vulnerable to extirpation during extreme events and/or unfavorable climatic periods.
Fin Whale	Low-Moderate	Moderate	Low-Moderate	Moderate	> Increased ocean temperatures > Declines in pH	Fin Whales are likely to have low sensitivity to changes in ocean temperature and other changing oceanographic conditions (e.g. pH, salinity) due to their migratory patterns and exposure to varying ocean conditions. However, the prey they feed on, such as euphausiids and copepods, may experience population declines as a result of increases in ocean temperature and decreases in pH. Limited prey availability could lead to decreased Fin Whale fecundity and population declines, though they may be able to adapt by switching target prey species (e.g. feeding more on small finfish as opposed to krill) depending on abundance.
Fisher	Moderate	Moderate	Moderate	Moderate	> Increased temperatures > Reduced snowpack > Altered fire regimes > Increased insect and disease outbreaks	Fishers exhibit some physiological sensitivity to temperature, as they behaviorally avoid extreme daily high temperatures by foraging during cooler periods of the day and seeking cooler habitats (e.g. dense canopies, riparian areas). Fishers also appear sensitive to snowpack; deep snow limits fisher movement, particularly juvenile dispersal. Reductions in snowpack could increase successful juvenile winter dispersal, alter competitive interactions (e.g. with Pacific Marten), or enhance predatory success. Warmer, drier conditions as well as altered fire regimes and insect and disease outbreaks that affect habitat extent and structural complexity influence the sensitivity of this species. Some disturbance (e.g. wind, fire, insects & disease) helps to create important habitat structures (e.g. snags, downed logs, den sites) while disturbances outside the natural range of variability may negatively impact this species.
Gray Whale	Moderate	High	Moderate	Moderate	> Increased ocean temperatures > Declines in pH	Due to their migratory patterns and broad range of habitat, Gray Whales are unlikely to be sensitive to changes in ocean temperature or chemistry. However, their sensitivity will be increased by potential changes in prey abundance. Decreases in pH could lead to declines in small invertebrates that Gray Whales feed on. Additionally, temperature increases could also lead to declines in invertebrate prey. For Atlantic Gray Whale populations, increases in sea surface temperature were thought to cause declines in amphipods, a primary prey for Gray Whales, leading to decreases in Gray Whale survival. At the northern end of their range in Alaska, Gray Whales may also experience

MAMMALS						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						disruptions in timing and distribution of food sources due to earlier season sea ice melt and increases in sea surface temperature. Gray Whales may also be sensitive to losses in key breeding habitat, like coastal lagoons in Mexico, due to sea level rise.
Gray Wolf	Low-Moderate	Moderate	Low-Moderate	Moderate	> Altered fire regimes > Increased insect and disease outbreaks	The Gray Wolf is a habitat and diet generalist. This species can thrive in a variety of habitats at different elevations, including forests, tundra, deserts, swamps, mountains, and prairies, where they feed mainly on a wide range of ungulate prey (small mammals, fish, and livestock are only a small portion of prey for most wolves). They require large, contiguous habitats and are therefore somewhat vulnerable to habitat fragmentation that restricts connectivity or brings them into great contact with people. Gray Wolves also display high reproductive and dispersal capacity. Their sensitivity to climate change will depend largely on the vulnerability of ungulate prey to disturbance regimes such as fire and disease; prey abundance may decline with larger and more intense fires and/or forest die off from insects as well as timber harvest.
Gray-tailed Vole	N/A	N/A	Unknown	N/A	None known	There is no information on the sensitivity of Gray-tailed Voles to climate change.
Grizzly Bear	Moderate	High	Moderate	Moderate	> Increased temperatures > Earlier snowmelt > Changes in precipitation timing	Grizzly Bears are diet generalists, feeding on a variety of food items, which may decrease overall sensitivity of this species. However, where and how food sources change could potentially exacerbate human/bear conflict and mortality. Additionally, warmer temperatures, delayed snowfall, and earlier snowmelt may alter the timing of den entry and exit, which could increase the potential for bear/human conflicts in spring and fall. Altered fire regimes may remove important habitat but could also open up new areas.
Hoary Bat	Low-Moderate	Low	Low-Moderate	Moderate	> Altered fire regimes > Changes in precipitation	The Hoary Bat displays low physiological sensitivity with a generalist's diet and a broad geographic distribution in both coniferous and deciduous forests across a wide temperature gradient from 32 to 71°F at elevations from 0 to 5315 feet in the Pacific Northwest. It is moderately sensitive to disturbance regimes, including fire and disease (e.g. white-nose syndrome). In general, climate changes that affect roosting and foraging habitat could negatively impact this species. For example, altered fire regimes could degrade or eliminate roosting habitats. Warmer, drier conditions as well as altered fire regimes and

MAMMALS						
Species	Overall Vulnerability	Overall Confidence	Sensitivity Rank	Exposure Rank	Summary of Exposure	Summary of Sensitivity
						increased invasive weeds may affect the availability of foraging resources to Hoary Bats. Changes in precipitation and/or water availability near maternity sites could affect reproductive output.
Humpback Whale	Low-Moderate	High	Low-Moderate	Moderate	> Increased ocean temperatures > Declines in pH	Humpback Whales migrate over great distances and occupy a broad range of ocean conditions; they are thus unlikely to have high physiological sensitivity to changes in ocean conditions. However, they are likely to have increased sensitivity due to potential declines in preferred food sources, such as small krill like euphausiids. Humpback Whale populations have been shown to be found in areas with high euphausiid production, thus any changes or declines in this food source (e.g. declining pH or increasing ocean temperatures) could have negative impacts on Humpback Whales such as decreased reproductive success and lower fecundity. Additionally, Humpback Whales often use shallow coastal lagoons for breeding; thus, sea level rise and potential loss of coastal habitat could also negatively influence this species.
Keen's Myotis	Moderate-High	High	Moderate-High	Moderate	> Increased temperatures	Keen's Myotis has a specialist's diet and its sensitivity is therefore tightly linked to both the timing and abundance of its prey. This species does not migrate, which makes it very sensitive to changes in microclimate, especially during winter hibernation; changes in temperature that drive the timing and length of winter hibernation could result in a mismatch in timing of insect prey availability and emergence from hibernation. It has a small geographic distribution; however, field identification of this species is difficult because of strong similarities with the western long-eared myotis, making statements about distribution, population size, and trends less certain. Cooler temperatures may energetically stress this species.
Killer Whale	Southern residents: Moderate-High; Transient/ Offshore: Low-Moderate	High	Southern residents: Moderate Transient/ Offshore: Low-Moderate	Southern residents: Moderate-High; Transient/ Offshore: Moderate	> Increased ocean and fresh water temperatures > Increased precipitation > Increased runoff > Declines in	Some Killer Whale populations occupy a wide temperature range; thus these are unlikely to experience physiological sensitivity to increasing ocean temperatures. However, their overall climate sensitivity is much higher due to potential declines in prey abundance. For the southern resident populations in particular, since they feed primarily on Chinook salmon, declines in Chinook abundance (stemming from a number of climate factors, such as increases in sea surface and fresh water temperature or higher levels of precipitation and runoff) could lead to decreases in survival and fecundity of southern resident Killer Whales.

MAMMALS						
Species	Overall Vulnerability	Overall Confidence	Sensitivity Rank	Exposure Rank	Summary of Exposure	Summary of Sensitivity
					pH	The transient population feeds on other marine mammals and has a larger variety of targeted prey and thus may be less sensitive; however, climate-induced changes in marine food webs (e.g. declines in small crustaceans that other marine mammals feed on due to acidification) could lead to declines in prey availability for transients. The offshore population is thought to feed mainly on sharks and other fish, but better dietary information is needed to draw firmer conclusions on impacts.
Kincaid Meadow Vole	Low-Moderate	Low	Low-Moderate	Moderate	> Increased temperatures > Changes in precipitation	There is no information on the sensitivity of Kincaid Meadow Voles to climate change. In general, this species likely does not exhibit much physiological sensitivity to climate change. Their association with damp meadows, marshy areas along creeks, and around lakes in the Columbia Basin seems likely to increase this subspecies' sensitivity if warmer and drier conditions degrade or eliminate these habitats in this region.
Lynx	High	High	High	High	> Increased temperatures > Reduced snowpack > Earlier snowmelt > Altered fire regimes > Increased insect and disease outbreaks	Lynx exhibit sensitivity to warming temperatures, decreased snowpack and earlier snowmelt, and altered fire regimes. Lynx are reliant on consistent snowpack during winter months for hunting, which provides them a competitive advantage over other predators. Lynx are usually considered hare specialists; increasingly variable timing of the arrival and melting periods of snowpack may lead to local extirpations of Snowshoe Hares, potentially affecting Lynx survivorship and recruitment. However, Lynx have been known to switch prey items when hares are limited. Altered fire regimes, insect and disease outbreaks that reduce mature stands, early seral-stage coniferous stands and/or dense understory cover further increases the sensitivity of this species.
Mazama Pocket Gopher	Low-Moderate	Moderate	Low-Moderate	Moderate	> Increased temperatures > Reduced soil moisture > Increased invasive species > Altered fire regimes	There is little to no information on the sensitivity of the Mazama Pocket Gopher to climate change. Mazama Pocket Gophers may exhibit some sensitivity to warmer, drier soil moisture conditions that make burrowing more challenging. Sensitivity of this species may be enhanced if invasive species such as Scotch broom increase under future climate conditions. However, prairie and grassland habitats may expand under future climate conditions (e.g. altered fire regimes that prevent conifer encroachment and/or adaptations to warmer, drier conditions), potentially benefitting this species.
Merriam's	Low-	Low	Low-	Moderate	> Drought	Merriam's Shrews likely have low physiological sensitivity to climate

MAMMALS						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
Shrew	Moderate		Moderate		> Increased flooding > Altered fire regimes	change, but may be sensitive to climate-driven changes in prey (e.g. small invertebrates) and habitat (e.g. arid shrub, shrub-steppe, and grasslands) availability. This species inhabits drier habitats than other shrew species, but may be sensitive to shifts in habitat availability due to drought, flooding, and fire, as well as habitat conversion (e.g. for agriculture).
Minke Whale	Low-Moderate	Moderate	Low-Moderate	Moderate	> Increased ocean temperatures > Declines in pH	Though limited information is available regarding the sensitivity to climate change of Minke Whales in the North Pacific, given their migration patterns and the wide range of conditions they experience, they are unlikely to have direct physiological sensitivity to climate-induced changes in ocean conditions. Their sensitivity will be higher due to potential fluctuations in preferred prey availability, like forage fish (e.g. Pacific Herring) and krill. Though warmer ocean temperatures could lead to declines in herring availability, studies have shown that Minke Whales are generalists and easily switch between different types of prey depending on abundance, which allows them to adjust well to seasonal variability in prey. Potential declines in krill abundance (e.g. declines in pH) could also increase sensitivity of Minke Whales.
North Pacific Right Whale	Moderate	Moderate	Moderate	Moderate	> Declines in pH > Altered circulation and/or upwelling patterns	Limited information is available regarding the sensitivity of North Pacific Right Whales to climate change. In general, their overall sensitivity is likely due to changes in abundance of their primary prey, copepods. Because North Pacific Right Whales are limited in the type of prey they can consume and require large aggregations of copepods for optimal feeding, declines in copepod production that could be triggered by changing ocean circulation or potential decreases in pH could greatly impact North Pacific Right Whales. Decreases in copepod abundance could lead to decreased calf and adult survival.
Northern Bog Lemming	Moderate-High	High	Moderate-High	Moderate-High	> Increased temperatures > Changes in precipitation > Drought > Altered fire regimes	The Northern Bog Lemming's physiological sensitivity to climate is likely moderate-high, as populations may have historically been reduced in size and number when the climate was warmer and the species is moderately restricted to relatively cool or cold environments in most of its range. Additionally, Washington is at the very southern edge of the species' geographic range, which may increase sensitivity to warming temperatures. The overall sensitivity of this species is likely driven by their dependence on cold, moist habitats such as peatlands and

MAMMALS						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						sphagnum moss, which are sensitive to changes in temperature and precipitation that lead to reduced moisture. Altered fire regimes that degrade or eliminate habitat may also impact this species.
Olympic Marmot	Moderate-High	High	Moderate-High	Moderate-High	> Increased temperatures > Reduced snowpack > Altered fire regimes	Olympic Marmots' sensitivity to climate is likely driven by their association with subalpine meadows that are vulnerable to increasing temperatures and reduced snowpack that result in habitat alterations (e.g. increased forest encroachment into meadows). Altered fire regimes may benefit subalpine meadows by preventing conifer encroachment. Olympic Marmots are also indirectly sensitive to climate change through effects on their primary predator, Coyotes. Warmer winters and lower snowpack are thought to allow Coyotes to persist at higher elevations than they could otherwise, increasing their predation on Olympic Marmots. Some evidence suggests that Olympic Marmots may also be directly sensitive to changes in snowpack; prolonged spring snow cover may be detrimental to survival and reproduction while sparse winter snow cover increases winter mortality.
Pacific Marten (Coastal population)	Moderate-High	High	Moderate-High	Moderate-High	> Reduced snowpack > Altered fire regimes > Drought	Sensitivity of the Pacific Marten to climate change will likely be driven by its habitat specificity and reliance on deep snowpack. Altered fire regimes and/or drought that result in reductions in the distribution and connectivity of important habitat features (e.g. large diameter tree stands with high canopy cover) may negatively impact this species. Pacific Martens rely on deep and persistent snowpack to exclude predators, provide high-quality hunting conditions, and provide winter resting and denning sites. Future reductions in snowpack may affect both the Pacific Marten and its prey species due to creation of more thermally variable subnivean space, and may alter Pacific Marten spatial distributions and/or competition with Fishers.
Preble's Shrew	Low-Moderate	Low	Low-Moderate	Moderate	> Changes in precipitation > Altered fire regimes > Increased invasive weeds	Limited information is available regarding the biology and ecology of Preble's Shrews and their potential response to climate change. Preble's Shrews appear to occupy a variety of habitat types throughout their range, but may be vulnerable to climate changes (e.g. precipitation, fire) that affect occupied habitat in Washington and/or prey availability (e.g. insects). Further expansion of cheatgrass could be detrimental to this species.
Pygmy Rabbit	Moderate-	Moderate	Moderate-	Moderate	> Altered fire	The Pygmy Rabbit is sensitive to changes in fire regimes such as extent

MAMMALS						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
	High		High		regimes > Increased invasive weeds	and frequency, especially fire-driven spread of the invasive cheatgrass that degrades the species' primary habitat and food source, sagebrush. Climate change will cause more frequent, intense, and larger wildfires. There are documented declines in Pygmy Rabbit populations with climate-driven changes in sagebrush habitat over the last 4,000 years.
Sea Otter	Low-Moderate	Moderate	Low-Moderate	Moderate	> Increased ocean temperatures > Declines in pH > Increased winter storm intensity and high surf conditions	Limited information is available regarding the response of Sea Otters to climate change. Their sensitivity will be primarily due to changes in prey abundance (e.g. Red Urchins, clams, bivalves), particularly since Sea Otters require large amounts of prey (approximately 30% of their body mass per day) to meet their metabolic requirements. Sea Otter prey may be sensitive to decreases in pH, and declines in prey abundance could impact Sea Otters, though their sensitivity may not be as high due to their ability to switch between prey species. Additionally, increasing temperatures could promote survival of marine bacterial pathogens that infect Sea Otters and cause mortality, though there are high levels of uncertainty regarding the level of increase in and potential effects of bacterial pathogens on sea otters. Sea Otters may also be sensitive to increased winter storm intensity and resulting high surf conditions that could result in higher mortality.
Sei Whale	Low-Moderate	Low	Low-Moderate	Low-Moderate	> Increased ocean temperatures > Altered circulation and/or upwelling patterns	Though very limited information is available regarding the sensitivity of Sei Whales to climate change, it is likely that their main sensitivity will be due to any changes in their preferred prey species (zooplankton [e.g. copepods], squid, and small schooling fish). Sei Whales feed primarily on zooplankton and are found in areas with high zooplankton concentrations; thus, any changes in zooplankton abundance, which could be caused by increases in sea surface temperature or changes in ocean circulation patterns, could limit prey availability for Sei Whales. However, because Sei Whales are able to target multiple types of prey, they may be less sensitive to changes in zooplankton abundance and may be able to switch to other prey species (e.g. small forage fish).
Shaw Island Townsend's Vole	N/A	N/A	Unknown	N/A	None known	There is no information on the sensitivity of Shaw Island Townsend's Voles to climate change.
Silver-haired Bat	Low-Moderate	Low	Low	Moderate	> Altered fire regimes	The Silver-haired Bat has a broad geographic distribution throughout North America and displays a preference for old-growth forests and

MAMMALS						
Species	Overall Vulnerability	Overall Confidence	Sensitivity Rank	Exposure Rank	Summary of Exposure	Summary of Sensitivity
						riparian areas between 0 to 6000 feet in elevation, although they also use caves and abandoned mines. There are both migratory individuals and year-round residents in Washington; during spring migration, there has been documented mortality at wind energy facilities. In general, climate changes that affect roosting and foraging habitat could negatively impact this species. For example, altered fire regimes that degrade or eliminate tree-roosting habitats such as large trees and snags may affect the Silver-haired Bat.
Sperm Whale	Low-Moderate	Moderate	Low-Moderate	Low-Moderate	> Increased ocean temperatures > Altered circulation and/or upwelling patterns	Though limited information is available regarding the sensitivity of Sperm Whales to climate change, their overall sensitivity is likely to be influenced by changes in the availability of their primary prey, squid. For Sperm Whales in the Gulf of California, abundance was linked to distribution and abundance of squid, and in the North Sea, higher sea surface temperatures and declines in squid abundance were thought to have potential links to increased Sperm Whale strandings. Thus, potential declines in squid populations (which could be prompted by changes in sea surface temperature or ocean circulation) could impact Sperm Whale populations. Given that males and females tend to occupy different habitats and ranges (with females preferring warmer, more southerly waters and males having a broader range), male and female Sperm Whales may exhibit different levels of sensitivity.
Spotted Bat	Low-Moderate	Low	Low-Moderate	Low-Moderate	> Changes in precipitation > Altered fire regimes	The Spotted Bat occupies a wide range of habitats in Washington from forests (e.g. ponderosa pine, Douglas-fir) and shrub-steppe to cliffs and water sources (e.g. marshes, open water, riparian areas) from 1000 to 2800 feet in elevation. There is limited information about this species' population size and trends and reproductive and wintering behavior, although there is some evidence that the Spotted Bat moves to lower elevations to overwinter. They appear to roost almost exclusively in the crevices of steep cliffs, which may make them vulnerable to recreational rock climbing or other manmade or natural destruction of cliff habitat (e.g. road construction, rockslides). Changes in precipitation that limit water availability directly or result in a decrease of prey could negatively affect this species. Increased fire and shrub-steppe degradation in the Columbia Basin could reduce habitat quality for this species.
Townsend's	Moderate-	Moderate	Moderate-	Moderate	> Increased	Townsend’s Big-eared Bats are found throughout much of the western

MAMMALS						
Species	Overall Vulnerability	Overall Confidence	Sensitivity Rank	Exposure Rank	Summary of Exposure	Summary of Sensitivity
Big-eared Bat	High		High		temperatures > Changes in precipitation > Altered fire regimes > Drought	United States; the species' distribution appears to be tightly linked to the presence of suitable roosting habitat and hibernacula located near foraging habitat. Roosting habitat selection is driven by temperatures within structures; in Washington, this habitat includes lava tube caves, mines, old buildings, bridges, and concrete bunkers. Increased temperatures may therefore reduce the availability of suitable hibernacula, forcing this species to move out of its current range to higher elevations or latitudes. Approximately 90% of the Townsend's Big-eared Bat's diet is composed of moths, making this species sensitive to prey availability (e.g. pesticides used to control outbreaks of moths). Altered disturbance regimes such as fire and drought that can destroy habitat will likely negatively impact this species. Changes in precipitation that limit water availability directly or result in a decrease of prey could negatively affect this species. In arid regions, periods of drought near maternity sites could affect reproductive output.
Townsend's Ground Squirrel	Moderate	Moderate	Moderate	Moderate	> Increased temperatures > Changes in precipitation > Drought > Altered fire regimes > Increased invasive species	Sensitivity of Townsend's Ground Squirrel is likely driven by their association with shrub-steppe, sagebrush, and grassland habitats. Warmer temperatures and changes in precipitation, including drought, could alter the phenology of important food plants, affecting the Townsend's Ground Squirrel's ability to accumulate adequate fat reserves before hibernation. Warmer, drier conditions that lead to more frequent and hotter fires and/or encourage the growth of invasive weeds (e.g. cheatgrass) may degrade or alter natural habitat for this species. Some evidence suggests that those individuals occurring in sagebrush habitat may be less sensitive to the impacts of drought (e.g. less decline in persistence and density, produce young) than those occurring in grassland habitats.
Washington Ground Squirrel	Moderate	Moderate	Moderate	Moderate	> Increased temperatures > Changes in precipitation > Drought > Altered fire regimes > Increased	Similar to Townsend's Ground Squirrel, sensitivity of Washington Ground Squirrels is likely driven by their association with shrub-steppe and grassland habitats, although they are able to inhabit a number of habitat subtypes which may decrease sensitivity. Warmer temperatures and changes in precipitation, including drought, could alter the quality and quantity of important forage plants, affecting juvenile survival as well as the ability to accumulate adequate fat reserves before hibernation. A series of drought years reduced the occurrence of

MAMMALS						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
					invasive species	Washington Ground Squirrels in 1994. Warmer, drier conditions that lead to more frequent and hotter fires and/or encourage the growth of invasive weeds (e.g. cheatgrass) may degrade or alter natural habitat for this species.
Western Gray Squirrel	Low-Moderate	Moderate	Low-Moderate	Moderate	> Increased temperatures > Changes in precipitation > Altered fire regimes > Increased disease outbreaks	Sensitivity of the Western Gray Squirrel in Washington is partially driven by their association with Oregon white oak habitats. Habitat quality in Washington is generally thought to be relatively poor due to a lower number of large-seeded, mast-bearing tree species, affecting Western Gray Squirrel population numbers. However, Oregon white oak habitats are projected to expand under warmer, drier conditions and may benefit Western Gray Squirrels in Washington. Altered fire regimes that further degrade habitat quality increase the sensitivity of this species. For example, the large Carlton Complex fire in the Okanogan in 2014 destroyed Western Gray Squirrel habitat and caused direct mortality to the species. Additionally, this species is sensitive to disease outbreaks (e.g. mange, Western equine encephalitis virus), which could become more frequent with warmer temperatures.
Western Spotted Skunk	Low	Low	Low	N/A	None known	There is little to no information on the sensitivity of the Western Spotted Skunk to climate change. Overall, it appears that this species exhibits low sensitivity due to its generalist diet and ability to occupy different habitats (e.g. wooded areas, tallgrass prairies, rocky canyons).
White-tailed Jackrabbit	Moderate	Moderate	Moderate	Moderate	> Drought > Altered fire regimes	The White-tailed Jackrabbit appears to be fairly tolerant of a wide temperature range in a variety of habitats within a broad range of elevations from 130 to 14000 feet, including prairie grassland, shrubland steppe, and montane shrublands. In areas in which populations of the White-tailed and Black-tailed Jackrabbits overlap and compete, the White-tailed Jackrabbit tends to move to higher elevations. Drought conditions that alter foraging habitats (e.g. bunchgrasses, rabbitbrush) may negatively impact this species. Altered fire regimes in the Columbia Basin could negatively affect this species.
Wolverine	Moderate-High	High	High	Moderate	> Increased temperatures > Reduced snowpack	Wolverines exhibit sensitivity to temperature and declines in snowpack. Wolverines are obligatorily associated with persistent spring snow cover, which provides critical thermal advantages such as predator refugia for denning females and young, preventing competition with other scavengers, and important prey caching/refrigeration areas.

MAMMALS						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						Temperature appears to play a role in fine-scale habitat selection, and may affect prey caching success. Warming temperatures and declines in snowpack could lead to decreased habitat patch size, quality, and connectivity; reduced success of caching/refrigeration of carrion prey with subsequent impacts on survivorship and recruitment; limited den sites and/or loss of thermal refugia important for juvenile survival; and/or increased dispersal costs.
Woodland Caribou	High	High	High	High	> Increased temperatures > Changes in precipitation > Altered fire regimes > Reduced snowpack > Earlier snowmelt > Increased insect and disease outbreaks	Woodland Caribou occupy higher elevations and rely on old-growth Engelmann spruce/subalpine fir and western red cedar/western hemlock forests that support arboreal lichens, which constitute a large portion of the Woodland Caribou diet. In combination with fire, warmer temperatures, precipitation changes, climate-driven increases in forest disease and insect mortality, and reduced snowpack and earlier snowmelt are likely to alter suitable habitat and predation risk for Woodland Caribou. Fire creates younger-age stands and edge habitat that attract deer, elk, and Moose; higher ungulate densities increases associated predator density, and these predators (e.g. bears, Gray Wolves, Cougars) prey opportunistically on Woodland Caribou. Woodland Caribou require deep, consolidated snow for movement at higher elevations during winter. Reduced snowpack and earlier snowmelt will affect the seasonal movements of Woodland Caribou and other ungulates, likely increasing predation risk by extending the length of time Woodland Caribou share habitat with other ungulates. In general, warmer and drier conditions will favor the expansion of deer, elk, and Moose by increasing overwinter survival, exacerbating predation risk and shifts in Woodland Caribou habitat.

Please be in touch if you'd like to view the excel spreadsheet.

C.2.2 Bird Vulnerability Rankings

BIRDS						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
American White Pelican	Low	Moderate	Low	Low	> Increases in precipitation that lead to flooding	American White Pelicans may be sensitive to climate change through changes to their breeding habitat. Increases in precipitation could affect flooding regimes in lakes and potentially limit nesting areas, although this species is highly adapted to take advantage of changing situations. Sensitivity may be increased by direct physiological responses to increases in temperature, such as potential vulnerability of chicks and juveniles to higher temperatures and earlier migration timing of adults, although this is highly uncertain.
Bald Eagle	Low-Moderate	Moderate	Low-Moderate	Moderate	> Altered fire regimes > High wind events > Increased temperatures > Changes in precipitation/ Altered hydrology	Bald Eagles may experience some sensitivity due to habitat and foraging requirements. Nest sites may be affected by altered disturbance regimes (e.g. fire and wind) while warmer temperatures and changes in precipitation could limit food availability and quality (i.e. salmon carcasses). However, Bald Eagles are opportunistic foragers and may be able to switch prey species.
Band-tailed Pigeon	Low-Moderate	Low	Low-Moderate	Low-Moderate	> Increased temperatures > Changes in precipitation > Altered fire regimes > This species is considered "climate threatened" (i.e. projected to lose >50% of current global range	Very little information exists regarding sensitivity of Band-tailed Pigeons to climate change. In general, this species may exhibit some sensitivity due to habitat requirements. Warmer temperatures and changes in precipitation that lead to declines in water levels may adversely affect this species. Similarly, altered fire regimes that lead to loss of forested habitat could negatively impact the species.

BIRDS						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
					by 2080) in the Audubon Birds and Climate Change Report.	
Barrow's Goldeneye	Moderate-High	Moderate	Moderate -High	Moderate -High	> Altered fire regimes > Declines in pH and dissolved oxygen > Reduced snowpack	Barrow's Goldeneye dependence on specific nesting, breeding, and wintering sites significantly increases this species' sensitivity to climate change. Disturbances such as fire could result in nesting tree loss, and changes in water chemistry (e.g. dissolved oxygen, pH) or temperature may lead to declines in food availability (e.g. mussels, aquatic insects, crustaceans, clams, etc.). Diminished snowpack that leads to wetland drying could also impact this species.
Black Scoter	Moderate	Low	Moderate	Moderate	> Increased ocean temperatures > Declines in pH, salinity, and/or dissolved oxygen	Very limited information is available regarding sensitivity of Black Scoter to climate change, particularly in Washington. Generally, this species appears to exhibit some sensitivity to climate change due to potential impacts on food availability. For example, changes in sea surface temperature, oxygen, salinity, and/or pH could lead to declines in marine forage (e.g. Pacific Herring, mussels).
Brown Pelican	Low-Moderate	Moderate	Low-Moderate	Moderate	> Sea level rise > Increased ocean temperatures > Altered circulation and/or upwelling patterns	Brown Pelicans are likely to have low physiological sensitivity to climate change. Their sensitivity may be increased by disturbances to coastal roosting sites from rising sea levels (e.g. sandbars and sand spits), which could limit availability of preferred roosting sites and force Brown Pelicans to select lower-quality roosting sites further away from foraging areas, though Brown Pelicans have been shown to adapt well to habitat disturbances. Sensitivity will also be affected by changes in preferred prey availability (e.g. Pacific Sardines, mackerel), which are likely to shift depending on ocean circulation patterns, such as El Niño Southern Oscillation (ENSO) and Pacific Decadal Oscillation (PDO). Warmer ocean temperatures and decreases in coastal upwelling could lead to declines in small forage fish, and thus limited prey availability for Brown Pelicans.

BIRDS						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
Burrowing Owl	Low-Moderate	Low	Low-Moderate	Low-Moderate	> Increased temperatures > Changes in precipitation	Burrowing Owls may exhibit low to moderate sensitivity due to climatic effects on breeding ranges, and decreasing habitat availability from land development pressures. Temperature-driven changes may cause this species to lose up to 77% of its existing breeding range and alter its winter range with only 33% remaining intact by 2080. Although temperature and precipitation changes may affect the availability of its preferred prey (insects), the Burrowing Owl has a generalist's diet, including other birds, small mammals (e.g. mice, voles), frogs, salamanders, and snakes. This species also depends upon other species such as American Badgers, prairie dogs and ground squirrels to create its nesting burrows.
Cinnamon Teal	Moderate	Low	Moderate	Moderate	> Increased temperatures > Reduced snowpack > Altered hydrology	Very limited information is available regarding sensitivity of Cinnamon Teal to climate change, particularly in Washington. Generally, their overall sensitivity is likely due to potential impacts on habitat availability and quality. Habitat factors such as amount of food and floods (i.e. spring floods and American Beavers) have been linked to breeding success. Declines in snowpack or altered flow regimes that affect these habitat factors could impact the number of Cinnamon Teal broods. If this species exhibits low phenotypic plasticity in terms of timing of breeding (i.e. less able to track environmental change), climate warming could also affect its breeding success due to timing mismatch.
Clark's Grebe	Moderate	Low	Moderate	Moderate	> Declines in pH > Changes in water level (e.g. water drawdowns or declines in precipitation)	Though there is limited information available regarding the sensitivity of Clark's Grebe to climate change, their primary sensitivity will occur through potential changes in small fish and invertebrate prey species that they target. Declines in pH could lead to declines in invertebrate prey and changes in water level in lakes and marshes could also lead to declines in available prey. This species also exhibits some sensitivity to fluctuating water level (high or low), which could lead to loss of eggs and nesting sites. In Washington, greater water drawdowns in reservoirs (i.e. because of expanded agricultural irrigation caused by climate change) may lead to increased nest loss.
Columbian Sharp-tailed Grouse	Moderate	Moderate	Moderate	Moderate	> Increases in spring precipitation	Columbian Sharp-tailed Grouse may exhibit some physiological sensitivity as young chicks may experience mortality due to prolonged wet spring weather. Overall sensitivity of this species is likely driven by

BIRDS						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
					> Altered fire regimes > Changes in precipitation overall > Increased invasive weeds	habitat specialization (e.g. grassland or shrub-steppe). Habitat suitability for this species could decrease or shift in response to altered fire regimes, invasive species spread (i.e. cheatgrass), and/or changes in precipitation.
Common Loon	Low-Moderate	Low	Moderate	Low-Moderate	> Increased temperatures (air and ocean) > Altered global climate patterns (i.e. El Niño)	Though limited information is available regarding the sensitivity of Common Loons to climate change, they may experience some direct sensitivity to climate change through northward contractions of their range with increasing temperatures and altered migration timing. Their sensitivity may be increased by changes to their prey and habitat. For instance, Pacific Herring, a primary food source for Common Loons, have previously experienced declines during El Niño years, leading to high mortality for Common Loons. More frequent and stronger El Niño conditions could lead to greatly decreased food supply for Common Loons.
Dusky Canada Goose	Low-Moderate	Low	Low-Moderate	Low-Moderate	> Uncertain. Loss of agricultural foraging habitats is primary threat. Winter wheat production is likely to increase in the short-term.	The physiological sensitivity of this species is likely low. However, their overall sensitivity may be slightly higher due to their winter habitat and foraging requirements. Changes in food abundance and availability on wintering grounds such as agricultural crop lands could affect mortality and survival rates, although impacts of climate change on these habitats is unclear.
Ferruginous Hawk	Low-Moderate	Low	Low-Moderate	Low-Moderate	> Drought > Increased storminess and winds	Little to no information exists regarding Ferruginous Hawk physiological sensitivity to temperature and precipitation. Overall sensitivity of this species may be enhanced due to prey specialization (i.e. jackrabbits, cottontail rabbits, ground squirrels, prairie dogs, pocket gophers) and habitat requirements (i.e. grasslands). Droughts that lead to declines in prey may adversely affect this species. Warmer

BIRDS						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						temperatures may benefit this species due to grassland expansion. Increased extreme weather events (e.g. heavy rain and high winds) may affect hawk reproduction and survival.
Flammulated Owl	Moderate	Moderate	Moderate	Moderate	> Increased temperatures > Changes in precipitation > Altered fire regimes	Flammulated Owls may be sensitive to temperature and moisture; upper limits of Flammulated Owl occupancy may be set by low nocturnal temperatures or high humidity, while lower limits may be set by high diurnal temperatures or high humidity. In addition, changes in temperature may alter the availability of primary prey species (e.g. insects), which may influence their distribution. Flammulated Owls are habitat specialists, requiring old-growth ponderosa pine and/or Douglas-fir stands, making them vulnerable to changes in habitat extent and quality due to shifting wildfire regimes, precipitation changes, and habitat loss or degradation.
Golden Eagle	Moderate	High	Moderate	Moderate	> Increased temperatures > Altered fire regimes	Golden Eagles may experience some sensitivity to warmer temperatures. For example, nest success and brood size is inversely related to days with temperatures >90°F. Sensitivity of this species is also influenced by foraging requirements (e.g. prey abundance and habitat), which can affect nest success and ability to lay eggs. Golden Eagles prey on hares, rabbits, ground squirrels, prairie dogs, and marmots, among others, and their ability to forage can be negatively affected when prey habitat is lost (e.g. wildfires) and/or prey abundance declines.
Great Gray Owl	Moderate	Low	Moderate	Moderate	> Increased temperatures > Altered fire regimes > High wind events	The plumage of Great Gray Owls may make this species somewhat sensitive to warmer temperatures, although featherless portions of the Great Gray Owl's underwing may help dissipate heat. Great Gray Owls may also exhibit some sensitivity to disturbance regimes such as fire and wind that destroy suitable habitat.
Greater Sage-grouse	Moderate-High	Moderate	Moderate -High	Moderate	> Drought and/or moisture stress > Increased	Greater Sage-grouse may exhibit some physiological sensitivity to drought conditions, which could result in decreased nest success and/or reduced chick survival. However, their overall sensitivity will be higher due to habitat and foraging requirements. Changes that reduce the availability and quality of sagebrush habitat (e.g. increased

BIRDS						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
					temperatures > Altered fire regimes	temperatures, drought and/or moisture stress, altered fire regimes), which Greater Sage-grouse depend on for forage, nesting, and brood-rearing, will adversely impact this species.
Harlequin Duck	Moderate-High	Low	Moderate-High	Moderate-High	> Changes in precipitation (timing and amount) > Earlier snowmelt > Increased flood events > Increased water temperatures > Declines in pH	The overall sensitivity of this species is likely moderate-high due to habitat (i.e. inland freshwater areas for breeding and coastal areas for wintering) and forage (i.e. aquatic invertebrates, Pacific Herring spawn) specialization. Breeding habitats and success as well as forage could be altered by flood events, while changes in temperature and pH could affect availability of key forage species. Additionally, earlier snowmelt can result in phenological mismatch with Harlequin Duck breeding ecology.
Lewis' Woodpecker	Low-Moderate	Moderate	Low-Moderate	Moderate	> Increased temperatures > Altered fire regimes	Warmer temperatures and precipitation changes influence sensitivity of Lewis' Woodpecker by affecting prey availability and habitat extent. Warmer temperatures are linked with higher surface-bark insect abundance and enhanced forage opportunities, which are thought to control the timing of Lewis' woodpecker breeding more than photoperiod. Altered wildfire regimes may affect habitat extent, although this species is often classified as a specialist in burned pine forest habitat.
Loggerhead Shrike	Low	Moderate	Low	Low-Moderate	> Increased temperatures > Drought > Increased storminess and/or high wind events	Loggerhead Shrikes likely exhibit low physiological sensitivity to climate change, although very little information currently exists on this topic. They are more sensitive to changes in prey abundance, habitat availability, and competition as a result of climate change. Loggerhead Shrikes prey on insects, reptiles, and small mammals and birds; insect prey, in particular, may vary in availability in response to temperature and drought. Loggerhead Shrikes favor open habitats with low-stature vegetation and available trees and shrubs for nesting; prairie/grassland habitats may expand with climate change, benefitting this species. They also successfully inhabit many altered systems (e.g. agricultural

BIRDS						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						fields). Wind, drought, and/or cold/wet weather events may contribute to nest or brood loss from nest damage or shifts in prey availability.
Long-tailed Duck	Low-Moderate	Low	Low-Moderate	Moderate	> Increased ocean temperatures > Sea level rise > Declines in dissolved oxygen and pH	Very limited information is available regarding sensitivity of Long-tailed Ducks to climate change, particularly in Washington. Generally, Long-tailed Ducks may exhibit some sensitivity to climate change due to potential impacts on food availability. Increases in temperature or sea level as well as changes in water chemistry that affect food sources such as Pacific Herring, crustaceans, mussels, etc. could impact this species.
Marbled Godwit	Moderate	Moderate	Moderate	Moderate	> Increased temperatures > Sea level rise	Marbled Godwits may experience some phenological sensitivity to increases in air temperature, as warmer temperatures could alter their migration timing and length of overwintering season in Washington. Temperature-induced alterations in migration timing may also affect breeding season timing and productivity. Overall sensitivity will be higher due to their dependence on intertidal sand and mudflats as foraging sites, which may decrease in extent due to sea level rise and coastal inundation. Because of their long legs, Marbled Godwits may be able to withstand coastal sea level changes by foraging in deeper waters.
Marbled Murrelet	Moderate	Moderate	Moderate	Moderate	> Increased ocean temperatures > Increased storminess and winds > Altered fire regimes	The main sensitivities of Marbled Murrelets to climate change will likely be due to potential changes in prey availability and habitat. Increasing sea surface temperatures could lead to declines in target prey abundance (e.g. Pacific Herring, Pacific Sand Lance, crustaceans) and declines in Marbled Murrelet productivity, though their ability to target multiple types of prey may help this species adapt to shifts in prey abundance. Alterations in nesting habitat, which occurs in inland mature and old growth forests, could also lead to declines in populations. Potential increased storminess and higher winds could impact nesting sites, as could drier, warmer conditions that lead to increased fires and more fragmented habitat for nesting.
Mountain Quail (Eastern WA only)	Moderate	Low	Moderate	Moderate	> Increased temperatures > Changes in precipitation	Mountain Quail inhabit dry areas and are dependent upon surface and preformed water availability. They exhibit sensitivity to increased temperatures or changes in precipitation that limit water supply. Increased fire severity and frequency that results in the conversion of

BIRDS						
Species	Overall Vulnerability	Overall Confidence	Sensitivity Rank	Exposure Rank	Summary of Exposure	Summary of Sensitivity
					> Altered fire regimes	suitable habitat also increases the overall sensitivity of this species.
Northern Spotted Owl	Moderate-High	Moderate	Moderate -High	West-side: Moderate East-side: Moderate -High	> Increased temperatures > Altered fire regimes > Increased insect outbreaks	This species exhibits some sensitivity to increased temperatures both directly (i.e. physiologically) and indirectly through effects on prey availability. This species also exhibits some sensitivity to altered disturbance regimes (i.e. fire and insect outbreaks) that lead to habitat changes. For example, in the eastern Cascades in Oregon, high severity wildfire has reduced the number of Northern Spotted Owls pairs in a USFS Ranger Unit. However, it appears that dense old forests may be relatively stable on the west side of the Cascades, while more active management may help address fire risk in dry east-side forests.
Oregon Vesper Sparrow	Low-Moderate	Low	Moderate	Low-Moderate	> Temperature changes (increase or decrease) > Changes in precipitation > Altered fire regimes	Oregon Vesper Sparrow sensitivity is largely driven by their dependence on open habitats, seeds, and insects. They nest and forage on the ground in open habitats (e.g. grasslands or shrublands with patchy vegetation and some bare ground). Increasing fire frequency, temperatures, and more variable precipitation may decrease habitat availability, quality and connectivity and/or alter foraging opportunities. They may have some physiological sensitivity; for example, low temperatures can undermine nestling growth by increasing thermoregulatory costs and/or decreasing insect prey availability.
Peregrine Falcon	Low	High	Low	Low	> No specific climate factors identified as it is a generalist	Overall sensitivity of Peregrine Falcons is likely low as this species utilizes a variety of habitat types and forages on a diversity of species.
Purple Martin	Low-Moderate	Low	Moderate	Low	> Changes in precipitation > Drought > Increased temperatures (possibly)	Purple Martins are sensitive to climate-driven changes in habitat and prey availability. Low temperature periods, particularly in conjunction with precipitation, limit foraging opportunities and are the largest contributor to Purple Martin mortality. Drought can also affect food availability. Warming temperatures are causing earlier spring insect availability peaks, but Purple Martins are long-distance migrants, and have not yet shown adaptive response in migration timing in response

BIRDS						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						to earlier spring food availability, at least in eastern U.S. populations. This mismatch between spring arrival and peak food availability contributes to undermined reproductive success and mortality; further studies are needed to see if selective pressures will advance migration timing for this species. Purple Martins nest in snags in secondary cavities formed by woodpeckers in montane areas and the Pacific lowlands; high habitat specificity makes them more vulnerable to climate change, although increasing fire frequency may increase habitat in burned forests.
Pygmy Nuthatch	Moderate	Moderate	Moderate	Moderate	> Altered fire regimes > Increased temperatures	Pygmy Nuthatches likely exhibit physiological sensitivity to cold temperatures, but utilize controlled hypothermia, communal roosting, and sheltered roosting cavities to survive cold periods. Pygmy Nuthatches are likely more sensitive to climate changes that affect foraging and nesting opportunities. Low- and moderate-severity, high-frequency fire helps maintain mature, open ponderosa pine habitat preferred by this species, but severe fire can destroy habitat in the short-term and inhibit ponderosa pine regeneration. Warming temperatures and xeric conditions may facilitate habitat expansion to higher elevations and into previously mesic areas, but can also lead to mortality of mature ponderosa pine individuals, affecting foraging and nesting opportunities. Warmer temperatures will likely increase insect foraging opportunities.
Red Knot	Moderate-High	Moderate	Moderate	Moderate -High	> Timing mismatches in favorable food, habitat, and weather conditions > Sea level rise > Declines in pH > Increased storminess	Red Knots are unlikely to have direct physiological sensitivity to changes in climate during their migration through Washington. However, their overall sensitivity will be higher due to their habitat and foraging requirements. Prime foraging areas, like mudflats, may decline due to sea level rise and coastal flooding of these habitats. Additionally bivalve populations, a major source of prey, may experience declines due to ocean acidification as well as changes in period of tide flat exposure and area of tide flat exposure. Preferred roosting sites such as sand islands and marshes may also become more limited due to rising sea level and/or increased storminess. In particular, changes in temperature leading to migration timing mismatches (i.e. timing of departure and arrival to coincide with favorable food, habitat and weather conditions) will negatively affect

BIRDS						
Species	Overall Vulnerability	Overall Confidence	Sensitivity Rank	Exposure Rank	Summary of Exposure	Summary of Sensitivity
						this species.
Red-necked Grebe	Low-Moderate	Low	Moderate	Low-Moderate	> Sea level rise > Increased storminess > Declines in pH	Very limited information is available regarding the sensitivity of Red-necked Grebes to climate change, particularly in Washington. Though Red-necked Grebes are unlikely to have direct physiological sensitivity to climate change, their sensitivity may be increased by climate-related changes in nesting and roosting habitat and prey availability. Sea level rise and coastal erosion could lead to declines in protected winter habitat. Increased storminess or wind may enhance vulnerability of nests. Additionally, juveniles feed mainly on invertebrates (e.g. crustaceans, mollusks); thus, any declines in these populations due to ocean acidification could limit prey availability for juvenile Red-necked Grebes.
Rock Sandpiper	Low-Moderate	Moderate	Low-Moderate	Moderate	> Sea level rise > Increases in wave action	Rock Sandpipers are likely to have low physiological sensitivity to increases in air temperature. However, their overall sensitivity will be higher due to their dependence on habitats that may be negatively impacted by climate change. Rising sea levels and increased wave action may disturb prime foraging area and lead to declines in food sources (e.g. intertidal mussels). Additionally, during their Alaskan breeding season, declines in sea ice due to rising air and ocean temperatures could limit breeding and roosting habitat.
Sage Thrasher	Moderate-High	Moderate	Moderate-High	Moderate	> Increased invasive weeds > Altered fire regimes > Increased temperatures > Changes in precipitation > Drought	As sagebrush obligates, Sage Thrashers are sensitive to climate changes that affect the extent of sagebrush habitat. Increasing fire frequencies, which are perpetuated by invasive species (e.g. cheatgrass), may reduce breeding habitat. Invasive species also degrade foraging opportunities in the sagebrush understory. Warming temperatures, precipitation variability, and drought are also likely to contribute to reductions in sagebrush habitat, negatively affecting Sage Thrasher reproduction and foraging.
Sagebrush Sparrow	Moderate-High	Low	Moderate-High	Moderate	> Increased invasive weeds > Altered fire regimes > Increased	Very limited information is available regarding sensitivity of Sagebrush Sparrows to climate change, particularly in Washington, and particularly due to recent taxonomic separation from Bell's Sparrow. However, as sagebrush obligates that require relatively intact and undisturbed sage for breeding, Sagebrush Sparrows are likely

BIRDS						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
					temperatures > Changes in precipitation > Drought	vulnerable to any climate changes that affect the extent, quality, and connectivity of sagebrush habitats. Increasing fire frequencies (due to climate change and perpetuated by invasive species, e.g. cheatgrass), warming temperatures, precipitation variability, and drought are likely to contribute to reductions in sagebrush habitat, negatively affecting this species. Sagebrush Sparrows may also be physiologically sensitive to warming temperatures; they avoid nesting on hot southwest aspects, and position nests to maintain airflow (which is hypothesized to ameliorate high temperatures during nesting periods).
Sandhill Crane (Greater)	Moderate	Low	Moderate	Moderate	> Drought > Altered hydrology	Sandhill Cranes appear to have low physiological sensitivity to changes in climate, although very little information currently exists on this topic. Sandhill Cranes generally require wetlands for nesting and some feeding, and prefer open water with little emergent vegetation for roosting. They are likely more sensitive to drought, low flows, or flooding that decrease available nesting, foraging, or roosting habitat.
Short-eared Owl (Western WA only)	Low	Low	Low-Moderate	Low	> No specific climate factors identified, although changes prey availability will negatively impact this species.	The Short-eared Owl has low physiological sensitivity due to its wide geographic distribution throughout North America, South America, Eurasia, and Africa; temperature does not appear to be a limiting factor for this species. Barn Owls may be direct competitors in some locations and displace Short-eared Owl populations. Variation in Short-eared Owl population size has been attributed to variations in small mammal abundance, thus this species is sensitive to changes in prey availability.
Short-tailed Albatross	Low	Low	Low-Moderate	Low	> Altered circulation and upwelling patterns	Although Short-tailed Albatross are unlikely to have physiological sensitivity to climate change and their breeding habitat is also unlikely to be affected by climate change, their sensitivity will be increased by potential shifts in prey availability. Given that Short-tailed Albatross primarily forage in areas with strong upwelling and high oceanic productivity along the continental shelf, potential shifts in ocean circulation could limit the availability of prey (e.g. squid, crustaceans, flying fish). Additionally, potential northward shifts of primary prey species like squid could result in a northward shift in Short-tailed Albatross populations.

BIRDS						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
Slender-billed White-breasted Nuthatch	Low-Moderate	Low	Low-Moderate	Low-Moderate	> Increased temperatures > Changes in precipitation > Altered fire regimes	This species likely has low physiological sensitivity to climate change, but little information is available. As a near-obligate of oak woodlands, this species is likely more sensitive to changes in mature oak woodland nesting and foraging habitat as a result of climate change. Snags and large, mature trees provide superior forage grounds and more space for nesting cavities, which are created by woodpeckers. Increased fire frequencies may help restore more open, mature oak habitat by reducing oak density and conifer encroachment. Fire and wind events may also create important edge openings preferred by this species. Temperature increases and precipitation changes may affect insect prey availability. Any reductions in oak habitat in response to climate change would likely negatively affect this species, for although they will nest in mixed deciduous-coniferous woodlands, past oak woodland loss has been associated with species extirpation from portions of Washington (e.g. Puget Sound).
Spruce Grouse	High	High	Moderate-High	High	> Altered fire regimes > Increased insect and disease outbreaks	Sensitivity of Spruce Grouse appears to be driven by their dependence on high elevation conifer forests. Spruce Grouse prefer relatively young successional stands of dense conifers, and populations appear to fluctuate over time in response to the degree of maturation of post-fire regrowth. Altered fire regimes and insect and disease outbreaks that lead to habitat degradation increase the sensitivity of Spruce Grouse to climate change.
Streaked Horned Lark	Moderate	Moderate	Moderate	Moderate	> Increased temperatures > Altered hydrology > Altered sediment accretion and erosion patterns (coastal)	Streaked Horned Larks likely exhibit physiological sensitivity to warmer temperatures; they have been documented to alter behavior during warm periods (e.g. forage in shade, use wings to shade nests) and heat events have interrupted breeding season in other states. Streaked Horned Larks prefer open habitats with ample bare ground and very sparse, low stature vegetation. Populations in grassland areas may benefit from increasing fire frequencies that reduce vegetative cover and shrub/tree encroachment. Populations nesting on the banks of the Columbia River may be vulnerable to shifting flow regimes and flood peaks. Populations in beach/dune habitats along the Washington coast are vulnerable to changing sediment accretion and erosion patterns, which can change in response to hydrological shifts, current changes, changing precipitation patterns, and human management practices.

BIRDS						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
Surf Scoter	Moderate-High	Moderate	Moderate -High	Moderate	> Increased ocean temperature > Sea level rise > Declines in dissolved oxygen and pH	Surf Scoter ducklings may exhibit some physiological sensitivity to climate change, as local weather conditions can affect survival. However, the overall sensitivity of Surf Scoters is primarily due to dependencies on specific breeding and foraging habitats that could be affected by climate change. Increases in temperature or sea level as well as changes in water chemistry may alter prey species composition and Pacific Herring spawn as well as alter subtidal foraging habitats. Surf Scoters are a late-nesting species and may also exhibit reduced flexibility in their timing of breeding, increasing their overall sensitivity to climate change.
Tufted Puffin	Moderate	Moderate	Moderate	Moderate	> Increased ocean temperatures > Increased storminess > Sea level rise	The main ways in which Tufted Puffins will be sensitive to climate change are through alterations to their breeding habitat and food supply. Predicted increases in sea surface temperature could lead to declines in abundance of zooplankton and small forage fish that this species preys upon. During breeding season Tufted Puffins stay close to their young and forage very close to breeding sites; thus, local declines in prey availability could lead to slower growth rates and reproductive failure, since adults will not be able to travel long distances to find alternate food sources. Additionally, sea level rise could impact breeding and foraging habitat for Tufted Puffins by altering the intertidal and subtidal areas where they deposit eggs and forage. Nesting habitat (i.e. burrowing sites) could also be impacted by increased storm frequency, which could result in damage and destruction of nesting areas.
Upland Sandpiper	Moderate	Low	Moderate	Moderate	> Increased temperatures > Changes in precipitation	Very limited information is available regarding the sensitivity of Upland Sandpipers to climate change, particularly in Washington. In the Midwest, Upland Sandpipers have exhibited some sensitivity to increasing temperatures, with earlier spring migration arrival positively correlated with increasing temperature. Declines in their preferred grassland and wet meadow habitat have already contributed to possible extirpation of the Upland Sandpiper in Washington; climate changes such as altered precipitation patterns that lead to further habitat loss will negatively impact this species. Altered fire regimes that remove shrubs and promote grasses may benefit this species.
Western	Low-	Low	Low-	Low-	>	Significant historical declines of Western Bluebird populations in

BIRDS						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
Bluebird (Western WA only)	Moderate		Moderate	Moderate	Colder/wetter spring conditions > Increased storminess (frequency or intensity)	western Washington are linked with wet conditions that affected prey availability, as well as habitat loss due to human activity. This species likely exhibits physiological sensitivity to temperature (particularly cold temperatures); adults elevationally migrate in response to shifting temperatures, and nestlings may become hypothermic during cold, wet periods. In addition, insect foraging opportunities decline during inclement weather, contributing to nestling mortality via starvation. Western Bluebirds nest in snag and tree cavities, and wildfire likely maintains preferred open woodland-prairie habitat and snag nesting opportunities, although it can eliminate specific nesting trees. Open woodland-prairie habitat in the Northwest may expand with drier conditions.
Western Grebe	Moderate	Low	Moderate	Moderate	> Changes in water level (e.g. increased water drawdowns or changes in precipitation) > Increased temperatures (air and ocean)	Disturbances to nesting habitats and declines in prey availability are the primary pathways through which Western Grebes will exhibit sensitivity to climate change. This species also exhibits some sensitivity to fluctuating water level (high or low), which could lead to declines in nesting habitats. In Washington, increased nest loss due to greater water drawdowns in reservoirs could occur due to the need for expanded agricultural irrigation caused by climate change. Also, damage associated with increased declines in preferred forage fish prey (primarily Pacific Herring) during the non-breeding season are thought to have led to a southern shift of the species to California, and further decreases in Pacific Herring (e.g. warmer ocean temperatures) could lead to additional Western Grebe population declines. Increases in air temperature could also prompt shifts in Western Grebe migration timing.
Western High Arctic Brant	Moderate	Moderate	Moderate	Moderate	> Sea level rise > Increased ocean temperatures > Increased storminess > Changes in salinity	This species likely exhibits moderate sensitivity to climate due to its habitat and foraging requirements. In particular, food abundance at wintering areas appears to have a direct effect on population reproduction. Key foraging areas such as eelgrass beds may decrease or increase due to changes in temperature or salinity, or sea level rise. Extreme events (e.g. severe winter weather) that reduce food abundance and availability could also affect this species (e.g. mortality).
Western	Moderate	Low	Moderate	Moderate	> Increased	Western Screech Owls may exhibit some physiological sensitivity to

BIRDS						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
Screech Owl					temperatures > Changes in precipitation timing > Drought > Altered fire regimes > Increased insect outbreaks	increased drought, as Western Screech Owl populations in southwestern Arizona declined 70% in three years during a drought. Changes in the timing of precipitation and warmer temperatures may alter timing of prey availability and abundance, with potential impacts on Western Screech Owl fecundity. Similar to the Northern Spotted Owl, this species may be sensitive to altered disturbance regimes (i.e. fire and insect outbreaks) that lead to habitat changes.
Western Snowy Plover	Moderate-High	Moderate	High	Moderate	> Sea level rise > Increased coastal erosion > Increased storminess/storm surge	The dependence of Western Snowy Plovers on coastal beaches and marshes as habitat for breeding and nesting increases their sensitivity to climate change. Sea level rise, beach erosion, and storm surges may cause declines in suitable habitat and decreases in local carrying capacity. Additionally, increased rainfall and storms could lead to declines in nesting success.
White-headed Woodpecker	Low-Moderate	Moderate	Low-Moderate	Moderate	> Increased temperatures > Altered fire regimes > Changes in precipitation	Sensitivity of White-headed Woodpeckers is influenced by warmer temperatures and precipitation changes that affect prey availability and habitat extent. Warmer temperatures are linked with higher surface bark insect abundance and enhanced forage opportunities. White-headed Woodpeckers require montane coniferous forests dominated by pines, which may be sensitive to precipitation changes and altered wildfire regimes, although these impacts could benefit the species (e.g. by providing more snags). Higher nesting and incubation success has been associated with warmer temperatures.
White-tailed Ptarmigan	High	High	High	High	> Increases in winter minimum temperatures > Increased temperatures overall	Physiological sensitivity of White-tailed Ptarmigan is likely low-moderate as this species is well-adapted to high altitude climatic variation and harsh conditions, although it has been shown that high winter minimum temperatures can retard population growth rates. The sensitivity of this species will primarily be driven by its dependence on high elevation habitats likely to be affected by or shrink in response to climate change, as well as its dependence on willow for foraging.

BIRDS						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
					> Reduced snowpack	
White-winged Scoter	Moderate	Moderate	Moderate	Moderate	> Increased ocean temperature > Sea level rise > Declines in dissolved oxygen and pH	Sensitivity of White-winged Scoters to climate change is primarily driven by their dependence on coastal estuaries, bays, and open coastlines with shallow water over shellfish beds and/or sand or gravel bottoms for foraging. Changes in ocean temperature, water chemistry, or sea level rise that affect food supply or foraging habitats could impact this species. White-winged Scoters are a late-nesting species and may also exhibit reduced flexibility in breeding timing, increasing their overall sensitivity to climate change.
Yellow-billed Cuckoo	Low-Moderate	Low	Low-Moderate	Moderate	> Increased temperatures > Increased drought and/or temperature change.	In Washington, Yellow-billed Cuckoos are likely sensitive to climate change through impacts in the availability of food resources. Warming temperatures may decrease the availability of food resources such as lepidopterans and/or lead to earlier spring peaks in food abundance which Yellow-billed Cuckoos may miss. Changes in precipitation or temperature may affect the peak timing of insect emergence or the timing of Yellow-billed Cuckoo arrival from wintering grounds, resulting in reduced food availability and possible impacts to breeding success.

C.2.3 Reptile and Amphibian Vulnerability Rankings

REPTILES AND AMPHIBIANS						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
California Mountain Kingsnake	Low-Moderate	Low	Moderate	Low-Moderate	> Changes in precipitation > Altered fire regimes	No information exists regarding the sensitivity of this species to climate change. Due to its occurrence in moist microhabitats in Oregon white oak-ponderosa pine forest, this species may have some sensitivity to altered precipitation and fire regimes that result in habitat loss or degradation. In Washington, species distribution is extremely small (around 20 miles) and is at the northern extent of the range, and occurrence is isolated and disjunct from the rest of the range by 200 miles.
Cascade	High	High	High	High	> Increased	Cascade Torrent Salamanders are likely highly sensitive to climate

REPTILES AND AMPHIBIANS						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
Torrent Salamander					temperatures (air and water) > Changes in precipitation > Reduced snowpack > Shifts from snow to rain > Earlier snowmelt	change due to their inability to tolerate desiccation and specialized habitat requirements. Declines in water availability and timing (e.g. reduced snowpack and earlier snow melt), as well as increased sedimentation (e.g. shifts from snow to rain), could decrease suitable headwater habitat for this species. This species may also be physiologically limited by high temperatures.
Columbia Spotted Frog (Columbia Basin only)	Moderate-High	Moderate	Moderate -High	Moderate	> Changes in precipitation (rain and snow) > Altered hydrology	Though there is very limited information available regarding the sensitivity of the Columbia Spotted Frog to climate change, their main sensitivity is likely to stem from any climate-induced changes in their pond and stream breeding habitat. If streams and ponds become drier, this could limit available breeding and juvenile habitat for this species, particularly for juveniles who are unable to travel long distances to more suitable habitat. Changes in precipitation patterns could also affect the Columbia Spotted Frog through alterations in breeding timing, egg survival, and availability of prey. However, predicted increases in temperature and milder winters may positively impact this species, as studies have shown that warmer and less severe winters are linked to increases in survival and breeding probability.
Columbia Torrent Salamander	Moderate-High	Moderate	High	Moderate -High	> Increased temperatures (air and water) > Changes in precipitation > Reduced snowpack > Shifts from snow to rain > Earlier snowmelt	Similar to Cascade Torrent Salamanders, Columbia Torrent Salamanders are likely highly sensitive to climate change due to their inability to tolerate desiccation and specialized habitat requirements. Declines in water availability and timing (e.g. reduced snowpack and earlier snow melt), as well as increased sedimentation (e.g. shifts from snow to rain), could decrease suitable headwater habitat for this species. This species appears to prefer north-facing, steep slopes, suggesting that this species may be sensitive to higher water temperatures and drier microclimates.

REPTILES AND AMPHIBIANS						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
Cope's Giant Salamander	Moderate-High	Moderate	Moderate -High	Moderate -High	> Increased temperatures > Changes in precipitation > Shifts from snow to rain	Cope's Giant Salamanders appear sensitive to temperature and precipitation factors that cause microhabitat desiccation as well as high flow events that degrade aquatic habitat. Elevated temperatures (although one study has shown these salamanders may tolerate a wider temperature range), increased solar radiation, and moisture loss, as well as declines in stream flow that reduce aquatic habitats, will likely negatively affect this species. Additionally, the species' occurrence in rain-on-snow transient zones makes it particularly sensitive to rain-on-snow events that result in high flow events and increased sedimentation. Range contractions are projected for the southern Cascades ecoregion, with possible expansions in the northern Cascades and/or low-mid elevation southern coastal streams.
Dunn's Salamander	Moderate-High	Low	Moderate -High	Moderate	> Increased temperatures > Changes in precipitation > Reduced snowpack > Earlier snowmelt	Little to no information exists regarding sensitivity of the Dunn's Salamander to climate change. This species may exhibit some sensitivity to warmer temperatures; however, its overall sensitivity is likely driven by its dependence on moist microhabitats that could be lost or degraded due to changes in snowpack amount and runoff timing.
Green Sea Turtle	Moderate	Moderate	Moderate -High	Low-Moderate	> Increased temperatures (air and ocean) > Declines in pH	Green Sea Turtles will be sensitive to climate change through a number of pathways. The species may respond directly to increases in temperature by shifts in sex ratios; warmer temperatures promote higher levels of female young. Increases in sea surface temperature could also lead to changes in migration patterns, nesting and hatch timing, and prompt mismatches between Green Sea Turtle abundance and prey availability. Increases in sand temperature could lead to higher levels of hatchling mortality. Indirectly, increases in sea surface temperature and decreases in pH could lead to alterations of macroalgal species that Green Sea Turtles prey upon and limit prey availability. Nesting habitat may also be impacted by sea level rise, increased storms, and coastal inundation, which could lead to lower reproductive success. The broad migratory range of Green Sea Turtles may allow them to search out different suitable nesting habitat,

REPTILES AND AMPHIBIANS						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						although nesting occurs outside of Washington.
Larch Mountain Salamander	Moderate-High	Moderate	High	Moderate	> Increased temperatures > Changes in precipitation	Sensitivity of Larch Mountain Salamanders to climate change is likely driven by its specialized habitat requirements; it prefers forested talus environments. This species also exhibits physiological sensitivity to temperature and precipitation, seeking out suitable microclimates (e.g. active at the surface during periods of high humidity and moderate temperature) as needed. Warmer and drier conditions could negatively affect this species through loss of suitable habitat, population isolation due to inability to disperse, and/or direct mortality because they depend on moist skin surfaces for oxygen uptake.
Leatherback Sea Turtle	Moderate	Moderate	Moderate -High	Low-Moderate	> Increased temperatures (air and ocean) > Changes in upwelling/circulation	Leatherback Sea Turtles will be sensitive to climate change through a number of pathways. They may respond directly to increases in temperature by shifts in sex ratios; warmer temperatures promote higher levels of female young. Increases in sea surface temperature could also lead to changes in migration patterns, northward species shift, and alterations in nesting and hatch timing, which could prompt mismatches between Leatherback Sea Turtle abundance and prey availability. Increases in sand temperature could lead to higher levels of hatchling mortality. Indirectly, increases in sea surface temperature and potential changes in upwelling and ocean circulation could affect the jellyfish that Leatherback Sea Turtles tend to prey upon and limit prey availability. Nesting habitat may also be impacted by sea level rise, increased storms, and coastal inundation, which could lead to lower reproductive success. The broad migratory range of Leatherback Sea Turtles may allow them to search out different suitable nesting habitat; they have low nest-site fidelity and thus may be able to switch nesting sites depending on conditions, although nesting occurs outside of Washington.
Loggerhead Sea Turtle	Moderate-High	Moderate	Moderate -High	Moderate	> Increased temperatures (air and ocean) > Declines in pH	Loggerhead Sea Turtles will be sensitive to climate change through a number of pathways. They may respond directly to increases in temperature by shifts in sex ratios; warmer temperatures promote higher levels of female young. Increases in sea surface temperature could also lead to changes in migration patterns and alterations in nesting and hatch timing, which could prompt mismatches between turtle abundance and prey availability; Loggerhead Sea Turtles were

REPTILES AND AMPHIBIANS						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						found to have decreased nesting abundance with warmer sea surface temperature. Increases in sand temperature could lead to higher levels of hatchling mortality. Indirectly, increases in sea surface temperature and decreases in pH could affect invertebrates (e.g. crabs, crustaceans, mollusks) that Loggerhead Sea Turtles prey on and potentially limit prey availability. Nesting habitat may also be impacted by sea level rise, increased storms, and coastal inundation, which could lead to lower reproductive success. The broad migratory range of Loggerhead Sea Turtles may allow them to search out different suitable nesting habitat, although nesting does not generally occur in Washington.
Night Snake	N/A	N/A	Unknown	Moderate	> Altered fire regimes > Increased invasive weeds	No information exists regarding the sensitivity of this species to climate change. Due to a lack of information on status and distribution in Washington, it is also difficult to estimate habitat sensitivities to climate change. In general, individuals associated with shrub-steppe vegetation are sensitive to altered fire regimes and invasive weeds that degrade or eliminate habitat.
Northern Leopard Frog	Moderate-High	Moderate	Moderate -High	Moderate	> Increased temperatures > Changes in precipitation > Altered hydrology	There is very limited information available regarding the sensitivity of Northern Leopard Frogs to climate change. They may experience some sensitivity to potential increases in temperature, which could lead to earlier timing of mating and breeding. Their sensitivity will be increased by potential climate-induced changes in their pond habitat. Adults need deep water, seasonal ponds, and wetlands for breeding habitat, and potential warmer and drier conditions could lead to declines in available breeding habitat. Drier conditions could even lead to localized population extinctions if breeding ponds become too shallow or disappear completely.
Olympic Torrent Salamander	High	High	High	Moderate -High	> Increased temperatures (air and water) > Changes in precipitation > Reduced snowpack > Shifts from	Overall sensitivity of this species is likely high due to high physiological sensitivity and specific habitat requirements—they are associated with permanent, high elevation, silt-free cold water sources with steep gradients. Increasing water temperatures and moisture loss will negatively impact this species, as it is desiccation-intolerant and cannot survive where water temperatures are too high. Reduced snowpack and shifts from snow to rain that lead to high flow events, erosion and scouring could reduce headwater riparian habitat for the Olympic Torrent Salamander.

REPTILES AND AMPHIBIANS						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
					snow to rain	
Oregon Spotted Frog	Moderate-High	Low	Moderate -High	Moderate	> Increased temperatures > Changes in precipitation > Altered hydrology	Very limited information is available regarding the sensitivity of the Oregon Spotted Frog to climate change. Its main sensitivity is likely to be due to changes in pond and wetland habitat. This species prefers shallow water ponds and vegetated pools for breeding and tadpole development. Potential warmer and drier conditions could lead to alterations in or disappearance of shallow ponds and changes in vegetation, which could impact breeding and tadpole survival. Additionally, warmer temperatures could lead to increases in invasive warm water predators that prey upon Oregon Spotted Frogs, like American Bullfrogs and some invasive fish species, thus leading to potential population declines.
Pygmy Horned Lizard	Moderate	Low	Moderate	Moderate	> Increased temperatures > Altered fire regimes > Increased invasive weeds	Little to no information exists regarding sensitivity of the Pygmy Horned Lizard to climate change. Physiological sensitivity of this species may be low to moderate, as it is inactive during cold weather or extended periods of heat. It appears to exhibit behavioral thermoregulation and burrows when inactive. Its inability to disperse long distances may increase sensitivity of this species. Overall sensitivity of this species is likely driven by its occurrence in shrub-steppe habitats, which are sensitive to altered fire regimes and invasive weeds.
Ring-necked Snake	Low-Moderate	Low	Low-Moderate	Moderate	> Changes in precipitation (rain and snow) > Altered fire regimes	Overall, there is a lack of information regarding sensitivity of the Ring-necked Snake to climate change. Individuals that occur in shrub-steppe habitats are often associated with riparian areas, and may have higher sensitivity due to drying habitat or altered fire regimes that degrade or eliminate habitat.
Rocky Mountain Tailed Frog	Moderate-High	Moderate	Moderate -High	Moderate -High	> Increased stream temperatures > Changes in precipitation > Altered fire regimes > Altered	Though there is limited information available regarding the sensitivity of the Rocky Mountain Tailed Frog to climate change, particularly for Washington populations, this species may exhibit some sensitivity to predicted increases in stream temperature with climate change. Rocky Mountain Tailed Frogs breed in streams and tadpoles spend many summers in stream habitat. Increases in stream temperature during the summer could lead to declines in tadpoles and adults. Both adults and juveniles may be able to avoid summer increases by migrating to

REPTILES AND AMPHIBIANS						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
					hydrology (i.e. increased flooding)	areas of the stream with cooler water, and some studies have shown an ability to withstand increases in stream temperature. Additionally, potential warmer and drier conditions and increases in wildfires could alter this species' preferred forest habitat and lead to reductions in population size. Increases in winter and spring precipitation could also lead to increased flooding events, disturbing available habitat for juveniles.
Sagebrush Lizard	Moderate-High	Low	Moderate -High	Moderate	> Altered fire regimes > Increased invasive weeds	Little to no information exists regarding sensitivity of the Sagebrush Lizard to climate change. It is likely that their overall sensitivity is greater since they are vegetated sand dune specialists. This habitat is vulnerable to invasive grasses or altered fire regimes that eliminate habitat.
Sharp-tailed Snake	Moderate	Low	Moderate	Moderate	> Increased temperatures > Changes in precipitation > Altered fire regimes	Overall, there is a lack of information regarding sensitivity of the Sharp-tailed Snake to climate change. Sensitivity of this species may be influenced by its occurrence along edges of coniferous or open hardwood forest, which are sensitive to warming temperatures, moisture stress, and changing fire patterns. This species may also exhibit some sensitivity to warmer temperatures and changes in precipitation since they are often associated with moist habitats.
Side-blotched Lizard	Moderate	Moderate	Moderate	Moderate	> Increased temperatures > Changes in precipitation > Altered fire regimes > Increased invasive weeds	Side-blotched Lizards appear to exhibit low reproductive sensitivity to climate, as warming temperatures (particularly warmer nights during breeding season) may increase reproductive output and subsequent survival. Further, Side-blotched Lizards appear to select specific temperature microhabitats, indicating behavioral thermoregulation. However, this species may exhibit some physiological sensitivity to changes in precipitation and warming winter temperatures (e.g. if warmer temperatures increase energetic demands). Overall sensitivity of this species is somewhat higher due to its association with shrub-steppe habitats, which are sensitive to altered fire regimes and invasive weeds that degrade or eliminate habitat.
Striped Whipsnake	Low-Moderate	Low	Low-Moderate	Moderate	> Changes in precipitation > Increased invasive weeds	Overall, there is a lack of information regarding sensitivity of the Striped Whipsnake to climate change. Sensitivity of this species may be influenced by its occurrence in shrub-steppe habitats, which are sensitive to changes in precipitation, invasive weeds, and altered fire regimes.

REPTILES AND AMPHIBIANS						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
					> Altered fire regimes	
Tiger Salamander	Moderate-High	High	High	Moderate	> Increased temperatures > Changes in precipitation and/or reduced snowpack > Drought	Little information exists regarding sensitivity of the Tiger Salamander to climate change, particularly in Washington. This species likely exhibits sensitivity to warmer and drier conditions that reduce aquatic breeding habitat, lead to desiccation, and/or result in an inability to move. Warmer temperatures and a decrease in total annual precipitation (including snow), as well as an increase in drought, has led to wetland desiccation and significant population declines in Yellowstone National Park. Timing of reproduction may also be affected by increasing temperatures.
Van Dyke's Salamander	Moderate-High	Moderate	High	Moderate	> Increased temperatures > Changes in precipitation > Reduced snowpack	Van Dyke's Salamanders are physiologically sensitive to heat and desiccation; this sensitivity to temperature and moisture changes is driven by respiration requirements; they depend on moist skin surfaces for oxygen uptake, although they can behaviorally regulate exposure by moving underground during times of higher temperatures and less precipitation. Sensitivity of this species is further increased due to their requirement of cool, forested stream habitat. Changes in hydrology (e.g. declines in snowpack or precipitation) that reduce seeps and springs habitat could negatively impact this species.
Western Pond Turtle	Low-Moderate	Low	Low-Moderate	Moderate	> Increased temperatures > Changes in precipitation (rain and snow) > Altered hydrology > Increased invasive weeds	Overall, there is a lack of information regarding sensitivity of the Western Pond Turtle to climate change. Sensitivity of this species may be affected by warming temperatures that influence offspring sex ratios, increasing the number of females even with small increases in temperature (<3˚F). However, it is possible that warming could benefit this species by providing more warm days for developing embryos, as Western Pond Turtles in Puget Sound are at the northern extreme of their range. Their dependence on aquatic habitats increases sensitivity of this species, as these habitats are likely to be affected by increasing temperatures and altered hydrology. Invasive weeds that overgrow nesting areas further increase sensitivity of this species.
Western Toad (W WA only)	Moderate	Moderate	Moderate to Moderate -High w/	Moderate	> Changes in precipitation (rain and snow)	Sensitivity of the Western Toad to climate change is primarily driven by its dependence on intermittent and permanent aquatic habitats (e.g. streams, seeps, wetlands, ponds, etc.) that may be lost or degraded due to changes in precipitation and altered hydrology. Desiccation of

REPTILES AND AMPHIBIANS						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
			synergistic impacts		> Altered hydrology	streams and pools along dispersal routes may create barriers to movement. Synergistic impacts such as climate changes combined with disease outbreaks increases sensitivity of this species. Physiological sensitivity of this species is unclear—some references cite sensitivities to temperature and moisture conditions, while others cite high adaptability to changes in these conditions. Greatest impacts to montane wetland-reliant taxa will most likely occur when landscapes primarily contain shallow wetlands at high risk of drying and are composed of multiple wetland types but deeper habitats are unsuitable (e.g. presence of introduced fish)
Woodhouse's Toad	Moderate-High	Moderate	Moderate -High	Moderate	> Increased temperatures > Changes in precipitation > Increased invasive weeds > Altered fire regimes	Juvenile toads avoid high temperatures and prefer lower temperatures when food is limited or under dry conditions. Tadpoles may be sensitive to low pH levels. Woodhouse's Toad may be better adapted to warmer, drier conditions due to their dry, leathery skin and ability to burrow to reduce exposure to high temperatures, although they need friable soils to burrow. Sensitivity of Woodhouse's Toad is greater due to their shrubland habitat specialization and dependence on wetlands and ponds for breeding, as well as low ability to disperse. Declines in shrub-steppe and wetland habitats due to climate change (i.e. changes in precipitation, invasive weeds, altered fire regimes) negatively affect this species.

C.2.4 Fish Vulnerability Rankings

FISH						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
Bluntnose Sixgill Shark	Low-Moderate	High	Low-Moderate	Moderate	> Increased ocean temperatures > Decreased oxygen	Though limited information is available regarding the sensitivity of Bluntnose Sixgill Sharks to climate change (particularly in Washington), there are a number of ways in which this species may be sensitive to changing ocean conditions. In general, increases in temperature may affect movement and migration patterns. The use of Puget Sound by juvenile Bluntnose Sixgill Sharks and their high site fidelity within Puget

FISH						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						Sound could make them sensitive to climate-related changes, such as increases in temperature or potential decreases in oxygen, which could potentially lead to declines in prey availability (e.g. other sharks and rays, fish). Because they are scavengers that target a wide range of prey, they may be able to shift prey species due to changes in abundance, but the high site fidelity of juveniles within Puget Sound, as well as their life history characteristics (slow growth, long generation times, low fecundity) may increase their sensitivity to climate-induced changes in Puget Sound. However, it appears Puget Sound Bluntnose Sixgill Sharks are part of a larger, much more broadly distributed population, suggesting possible resilience to climate impacts.
Bocaccio (Puget Sound/Georgia Basin DPS)	Moderate-High	Moderate	Moderate	Moderate-High	> Increased ocean temperatures > Sea level rise > Declines in pH > Decreased oxygen	The main sensitivity of Bocaccio to climate change is likely to stem from changes to their prey base and resultant reductions in the likelihood of successful recruitment events. Warmer ocean conditions could lead to decreases in prey (e.g. krill, copepods) for both juveniles and adults, prompting decreases in adult fecundity and juvenile survival. Warmer waters could also lead to decreased success of recruitment events. Additionally, nearshore habitat loss due to sea level rise could impact juvenile survival, as juveniles tend to use nearshore habitat as nursery and foraging area. Deepwater coral habitat, which many adult Bocaccio use, may also decrease due to acidification, further reducing available habitat. Decreased oxygen levels may have direct physiological effects on Bocaccio, leading to higher levels of mortality across various life stages. Due to their long life cycles and generation times, adults may be able to persist through short term pulses of negative ocean conditions (e.g. years with warmer sea surface temperature), though conversely, their low productivity could make it difficult for populations to recover from climate-related declines.
Broadnose Sevengill Shark	Moderate	Moderate	Moderate	Moderate	> Increased ocean temperatures > Altered circulation patterns > Decreased	Though limited information is available regarding the sensitivity of Broadnose Sevengill Sharks to climate change (particularly in Washington), there are a number of ways in which this species may be sensitive to changing ocean conditions. In general, increases in temperature may affect movement and migration patterns of sharks. Currently the warmer summer waters of Willapa Bay, where most Broadnose Sevengill Sharks are found, are thought to have foraging and

FISH						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
					oxygen	reproductive benefits for sharks, but shifts in temperature, changes in ocean circulation that lead to decreased productivity, or decreases in oxygen and resulting declines in prey availability could make this area less optimal. Because Broadnose Sevengill Sharks target a broad range of prey, they may be more adaptable to shifts in prey composition, but their high site fidelity to particular areas in Willapa Bay, as well as their life history characteristics (slow growth, long generation times, low fecundity) may increase their sensitivity to any climate-induced changes in habitat conditions. Overall, the generalist nature of their diet, ability to migrate to and from California and use diverse estuaries, and general hardiness suggest limited climate-related impacts.
Brown Rockfish	Moderate-High	Moderate	Moderate	Moderate-High	> Increased ocean temperatures > Sea level rise > Declines in pH > Decreased oxygen	The main sensitivity of Brown Rockfish to climate change is likely to stem from changes to their prey base. Warmer ocean conditions could lead to decreases in prey (e.g. zooplankton) for both juveniles and adults, prompting decreases in adult fecundity and juvenile survival. Additionally, nearshore habitat loss due to sea level rise could impact juvenile survival, as juveniles tend to use nearshore habitat as nursery and foraging area. Deepwater coral habitat, which many adult rockfish use, may also decrease due to acidification, further reducing available habitat. Decreased oxygen levels may have direct physiological effects on Brown Rockfish, leading to higher levels of mortality across various life stages. Due to their long life cycles and generation times, adults may be able to persist through short term pulses of negative ocean conditions (e.g. years with warmer sea surface temperature), though conversely, their low productivity could make it difficult for populations to recover from climate-related declines.
Bull Trout - Coastal Recovery Unit	Moderate-High	High	Moderate-High	Moderate	> Increased water temperatures > Altered runoff timing > Increased winter/spring flood events > Lower	Sensitivity of Bull Trout is primarily driven by water temperature. Bull Trout are the southernmost species of Western North American char and have lower thermal tolerance than other salmonids they co-occur with. The upper incipient lethal temperature for Bull Trout was found to be 70˚F, whereas the optimal temperatures for growth were in the range of 50-59˚F. Thus Bull Trout have a similar thermal optima to the salmonids they co-occur with, yet a lower thermal tolerance, indicating they have a narrower thermal niche and higher sensitivity to temperature. Indeed the geographic distribution of Bull Trout, and the

FISH						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
					summer flows	persistence of populations during contemporary warming has been most strongly related to maximum water temperature. The ability of Bull Trout to persist in sub-optimally warm temperatures likely depends on food abundance. As temperature increases metabolic costs, the extent to which Bull Trout can maintain positive energy balance depends on its ability to find food. Bull Trout historically relied heavily on salmon as a food resource and may be less resilient to temperatures in areas where foraging opportunities of salmon eggs and juveniles have declined. Invasive chars (Brook and Lake Trout) now reside in many headwater streams and lakes, and may exclude Bull Trout from these potential coldwater refuges, increasing their sensitivity to warming. Bull Trout sensitivity to flows is likely to occur during two critical periods: 1) direct effects of altered runoff timing and magnitude on emerging fry in late winter/spring, and 2) indirect effects of low summer flows on all life phases of Bull Trout by mediating the duration and magnitude of thermal stress events.
Bull Trout - Mid-Columbia Recovery Unit	Moderate-High	High	Moderate-High	Moderate	> Increased water temperatures > Altered runoff timing > Increased winter/spring flood events > Lower summer flows	Sensitivity of Bull Trout is primarily driven by water temperature. Bull Trout are the southernmost species of Western North American char and have lower thermal tolerance than other salmonids they co-occur with. The upper incipient lethal temperature for Bull Trout was found to be 70˚F, whereas the optimal temperatures for growth were in the range of 50-59˚F. Thus Bull Trout have a similar thermal optima to the salmonids they co-occur with, yet a lower thermal tolerance, indicating they have a narrower thermal niche and higher sensitivity to temperature. Indeed the geographic distribution of Bull Trout, and the persistence of populations during contemporary warming has been most strongly related to maximum water temperature. The ability of Bull Trout to persist in sub-optimally warm temperatures likely depends on food abundance. As temperature increases metabolic costs, the extent to which Bull Trout can maintain positive energy balance depends on its ability to find food. Bull Trout historically relied heavily on salmon as a food resource and may be less resilient to temperatures in areas where foraging opportunities of salmon eggs and juveniles have declined. Invasive chars (Brook and Lake trout) now reside in many headwater streams and lakes, and may exclude Bull Trout from these

FISH						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						potential coldwater refuges, increasing their sensitivity to warming. Bull Trout sensitivity to flows is likely to occur during two critical periods: 1) direct effects of altered runoff timing and magnitude on emerging fry in late winter/spring, and 2) indirect effects of low summer flows on all life phases of Bull Trout by mediating the duration and magnitude of thermal stress events.
Burbot	Moderate	Low	Moderate	Moderate	> Increased water temperatures > Altered flow regimes	Burbot is a cold-adapted species whose distribution, behavior, and physiology is limited by warmer water temperatures. Warmer water temperatures limit dispersal to more southerly locations and influence behavior and physiology in current habitat. Burbot have been documented to seek out cool-water thermal refugia near lake inflows, and warmer water temperatures have been documented to decrease survival and have variable impacts on growth of hatchery-raised individuals. Shifts in streamflow may affect spawning migrations and/or spawning synchrony of this winter-spawning species. For example, reduced streamflows and lake/reservoir levels can reduce or degrade spawning and rearing habitat, while high winter flows may impede upstream movements of adult Burbot.
Canary Rockfish (Puget Sound/Georgia Basin DPS)	Moderate-High	Moderate	Moderate	Moderate-High	> Increased ocean temperatures > Sea level rise > Declines in pH > Decreased oxygen	The main sensitivity of Canary Rockfish to climate change is likely to stem from changes to their prey base. Warmer ocean conditions could lead to decreases in prey (e.g. copepods, crustaceans, euphausiid eggs) for both juveniles and adults, prompting decreases in adult fecundity and juvenile survival. Additionally, nearshore habitat loss due to sea level rise could impact juvenile survival, as juveniles tend to use nearshore habitat as nursery and foraging area. Deepwater coral habitat, which many adult rockfish use, may also decrease due to acidification, further reducing available habitat. Decreased oxygen levels may have direct physiological effects on Canary Rockfish, leading to higher levels of mortality across various life stages. Due to their long life cycles and generation times, adults may be able to persist through short term pulses of negative ocean conditions (e.g. years with warmer sea surface temperature), though conversely, their low productivity could make it difficult for populations to recover from climate-related declines.
China Rockfish	Moderate-	Moderate	Moderate	Moderate-	> Increased	The main sensitivity of China Rockfish to climate change is likely to stem

FISH						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
	High			High	ocean temperatures > Sea level rise > Declines in pH > Decreased oxygen	from changes to their prey base. Warmer ocean conditions could lead to decreases in prey (e.g. zooplankton) for both juveniles and adults, prompting decreases in adult fecundity and juvenile survival. Additionally, nearshore habitat loss due to sea level rise could impact juvenile survival, as juveniles tend to use nearshore habitat as nursery and foraging area. Deepwater coral habitat, which many adult rockfish use, may also decrease due to acidification, further reducing available habitat. Decreased oxygen levels may have direct physiological effects on China Rockfish, leading to higher levels of mortality across various life stages. Due to their long life cycles and generation times, adults may be able to persist through short term pulses of negative ocean conditions (e.g. years with warmer sea surface temperature), though conversely, their low productivity could make it difficult for populations to recover from climate-related declines.
Columbia River Chum Salmon ESU	Moderate	High	Moderate	Moderate	> Increased water temperatures (freshwater and sea surface) > Increased winter/spring flood events	Washington is near the southern extent of the geographic range for chum salmon, which suggests they may be sensitive to increases in water temperature (freshwater and ocean). Chum salmon incubate embryos in freshwater, but juveniles migrate to estuaries as age-zeros, typically during the spring; the spawning migrations of adult fish typically occur in late fall. Thus Columbia River chum salmon are unlikely to be exposed to thermal stress in the freshwater phase of their life history. However, altered freshwater thermal regimes could affect chum salmon by altering their phenology and potentially creating mismatch between arrival in estuaries and the timing of ideal ecological conditions in estuarine habitats. Chum salmon will likely be most sensitive to changes in marine thermal regimes. In general, Pacific salmon survival is positively related to sea surface temperatures (SST) at the northern extent of their distribution, and negatively related at the southern extent. However, recent evidence suggests that chum salmon may be less sensitive to SST at the southern extent of their range compared with pink and sockeye. Chum salmon spawn in late fall at southern latitudes and their embryos are vulnerable to flood events that can scour redds or bury them in silt. Chum may be vulnerable to altered flow regimes that include increased flood severity, particularly in watersheds where land use has enhanced stream flashiness.

FISH						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
Copper Rockfish	Moderate-High	Moderate	Moderate	Moderate-High	> Increased ocean temperatures > Sea level rise > Declines in pH > Decreased oxygen	The main sensitivity of Copper Rockfish to climate change is likely to stem from changes to their prey base. Warmer ocean conditions could lead to decreases in prey (e.g. zooplankton) for both juveniles and adults, prompting decreases in adult fecundity and juvenile survival. Additionally, nearshore habitat loss due to sea level rise could impact juvenile survival, as juveniles tend to use nearshore habitat as nursery and foraging area. Deepwater coral habitat, which many adult rockfish use, may also decrease due to acidification, further reducing available habitat. Decreased oxygen levels may have direct physiological effects on Copper Rockfish, leading to higher levels of mortality across various life stages; in the past, Copper Rockfish have exhibited high mortality rates during extreme hypoxic events. Due to their long life cycles and generation times, adults may be able to persist through short term pulses of negative ocean conditions (e.g. years with warmer sea surface temperature), though conversely, their low productivity could make it difficult for populations to recover from climate-related declines.
Eulachon (southern DPS)	Moderate-High	Moderate	High	Moderate	> Altered runoff timing and magnitude > Increased water temperatures (fresh and ocean)	Eulachon are vulnerable to climate-driven changes in both their oceanic rearing and freshwater spawning habitat. Eulachon exhibit site fidelity to specific spawning rivers, limiting the opportunity for adults and juveniles to move in response to changing nearshore-rearing and spawning habitat conditions. Eulachon spawn prior to the spring freshet, and egg hatch is correlated with peak spring flows to facilitate emigration. Precipitation changes, reduced snowpack, and earlier snowmelt all contribute to shifts in streamflow timing and magnitude, which could alter Eulachon spawning time and/or cause earlier emigration. Early emigration could contribute to oceanic prey mismatch and Eulachon mortality if larvae/juveniles arrive to marine rearing habitat prior to coastal upwelling initiation, which is projected to occur later in response to warmer ocean temperatures. Warming ocean temperatures may also affect eulachon forage opportunities and marine survival by affecting the abundance and composition of copepod communities, key prey for larval eulachon. Warming ocean temperatures have also facilitated the expansion of Pacific Hake, which prey upon and compete with Eulachon.
Green	Low-	Low	Low-	Moderate	> Increased	Limited information is available regarding the sensitivity of Green

FISH						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
Sturgeon (southern DPS)	Moderate		Moderate		ocean temperatures > Declines in pH	Sturgeon to climate change (particularly in Washington). Green Sturgeon are wide-ranging migrants, spawning in California and appearing in Washington's coastal waters, estuaries and watersheds in late summer. Although they may be sensitive to hydrological and temperature shifts in their natal watersheds, vulnerability to climate change in Washington is likely linked with changes in the marine environment. In general, water temperatures influence fish distribution, physiology, and biology. Green Sturgeon likely exhibit some physiological sensitivity to water temperature increases. A study in the Klamath and Rogue River basins found that bioenergetic performance peaked at water temperatures between 59-66°F. A separate study theorized that Green Sturgeon utilize warmer estuarine habitats in Washington during summer to maximize growth potential. Climate change impacts (e.g. decreased pH) may also affect Green Sturgeon prey (e.g. benthic organisms such as shrimp, amphipods, small fish, mollusks).
Greenstriped Rockfish	Moderate-High	Moderate	Moderate	Moderate-High	> Increased ocean temperatures > Sea level rise > Decreased oxygen	The main sensitivity of Greenstriped Rockfish to climate change is likely to stem from changes to their prey base. Warmer ocean conditions could lead to decreases in prey (e.g. copepods, larger crustaceans and cephalopods for adults) for both juveniles and adults, prompting decreases in adult fecundity and juvenile survival. Additionally, nearshore habitat loss due to sea level rise could impact juvenile survival, as juveniles tend to use nearshore habitat as nursery and foraging area. As Greenstriped Rockfish tend to prefer soft sediment and muddy, sandy areas as habitat, they will be less sensitive to loss of deepwater coral habitat due to decreased pH than other rockfish species. Decreased oxygen levels may have direct physiological effects on Greenstriped Rockfish, leading to higher levels of mortality across various life stages. Due to their long life cycles and generation times, adults may be able to persist through short term pulses of negative ocean conditions (e.g. years with warmer sea surface temperature), though conversely, their low productivity could make it difficult for populations to recover from climate-related declines.
Hood Canal Summer	Moderate-High	High	Moderate-High	Moderate-High	> Increased water	Washington is near the southern extent of the geographic range for chum salmon, which suggests they may be sensitive to increases in

FISH						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
Chum Salmon ESU					temperatures (freshwater and sea surface) > Increased winter/spring flood events > Lower summer flows	water temperature (freshwater and ocean). Chum salmon incubate embryos in freshwater, but juveniles migrate to estuaries as age-zeros, typically during the spring; the spawning migrations of adult fish typically occur in early fall. Thus Chum Salmon may be sensitive to lower summer flows during adult migration to spawning areas. Altered freshwater thermal regimes could affect chum salmon by altering their phenology and potentially creating mismatch between arrival in estuaries and the timing of ideal ecological conditions in estuarine habitats. Chum Salmon will likely be most sensitive to changes in marine thermal regimes. In general, Pacific Salmon survival is positively related to sea surface temperatures (SST) at the northern extent of their distribution, and negatively related at the southern extent. However, recent evidence suggests that Chum Salmon may be less sensitive to SST at the southern extent of their range compared with Pink and Sockeye. Chum Salmon embryos are vulnerable to flood events that can scour redds or bury them in silt. Chum may be vulnerable to altered flow regimes that include increased flood severity, particularly in watersheds where land use has enhanced stream flashiness.
Inland Redband Trout (landlocked populations)	Moderate-High	Low	Moderate	Moderate-High	> Increased water temperatures > Altered timing/magnitude of spring runoff > Lower summer flows	In general, there is little information on Inland Redband Trout sensitivity to climate change. Inland Redband Trout are likely sensitive to increasing water temperatures and altered flow regimes. While Inland Redband Trout can persist in desert streams that often exceed 68˚F through what appears to be local physiological adaptation, increased water temperatures pose a threat to this species because though their thermal optima is higher than other salmonids, their thermal maxima is similar. Further, warming temperatures may lead to increased non-native species invasion or competition with native "cool water" fishes such as cyprinids and catostomids. Inland Redband Trout spawn in the spring, thus their embryos and recently emerged fry may be sensitive to changes in the timing and magnitude of spring runoff. Lower summer flows may decrease habitat volume and access to headwater reaches for this species. Inland Redband Trout exhibit broad phenotypic (e.g. age at maturity, frequency and timing of spawning, temperature tolerance, etc.) and life history diversity, which may decrease overall sensitivity of this species.

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Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
Lake Chub	Moderate	Low	Moderate	Moderate	> Increased water temperatures > Altered flow regimes > Increased sedimentation	Although little information regarding the sensitivity of Lake Chub to climate change is available for Washington, analyses from other regions (e.g. Wyoming, South Dakota, Colorado) indicate that this species may be vulnerable to changes in water temperature, water levels, and turbidity. Lake Chub occupy cool, clear water, spawn in stream or lake margins, and are obligatory sight feeders. Water temperatures affect developmental rates and likely influence spawning timing. Shifting flow regimes (including low flows and flood frequency/ magnitudes), drought conditions, and warming temperatures could affect rearing success and adult survival, particularly for fragmented or isolated populations. In addition, post-wildfire sedimentation could affect water turbidity and affect foraging success.
Leopard Dace	Moderate-High	Low	Moderate	Moderate-High	> Increased water temperatures > Lower summer flows > Altered timing/magnitude of spring floods	Although little information is available regarding the sensitivity of Leopard Dace to climate change (particularly in Washington), as a cool-water associate, this species is likely sensitive to increasing water temperatures (upper lethal limit is 73°F). As a summer spawning species that occupies creeks, shallow lacustrine habitats, and low- to medium-sized rivers, Leopard Dace may also be vulnerable to decreasing summer streamflows, particularly if they exacerbate temperature increases. Increasing temperatures and shifting flow and flood regimes may also affect prey availability (e.g. aquatic insect larvae, earthworms). For example, spring floods were found to be a key delivery mechanism of earthworms, which constitute a large portion of Leopard Dace spring diet.
Lower Columbia Chinook Salmon ESU	Moderate-High	High	Moderate-High	Moderate-High	> Increased freshwater temperatures > Lower summer flows > Increased winter/spring flood events	In general, Chinook Salmon appear sensitive to warmer water temperatures, low flows, and high flows. Warmer water temperatures can affect physiological performance and energy budgets, as well as developmental rates and the timing of key lifecycle transitions (i.e. phenology). Lower stream flows have been linked to mass mortality events of Chinook Salmon. Extreme high flows can reduce the likelihood of egg survival during incubation, and both low and high flows can affect adult migration. Temperature: Chinook Salmon appear sensitive to elevated freshwater temperatures both as juveniles rearing in tributary streams and as

FISH						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						adults migrating up river networks to spawn. Water temperatures positively affect metabolic costs, so warming reduces the amount of time a spawning adult can persist in freshwater and decreases the total distance a fish can migrate on a given level of energy stores. Indeed, Chinook Salmon that migrate slower, and accrue more energy loss, have higher mortality rates in the Columbia River. In addition to energetic effects, temperatures in excess of ~63˚F (the approximate temperature at which the maximum rate of physiological processes is observed for Chinook Salmon) begin to thermally stress individuals, making them more vulnerable to pathogens and other health issues. Episodes of high water temperature have led to large mortality events in several river systems within or adjacent to the Columbia River Basin. In the Columbia River, cool tributaries provide refuge from heat stress for migratory Chinook Salmon, and may reduce the sensitivity of this species to warming temperatures. However, time spent in thermal refugia can come at a price, such as increased exposure to angling pressure, later arrival at spawning grounds, and other factors. Warming temperatures in the streams where Chinook Salmon rear can have negative effects even when temperatures are not near the thermal maxima of the species. For example, the strength of density dependence in fish growth was positively related to water temperature, which corroborates the mechanistic predictions of bioenergetics models. This suggests warming temperatures decrease the carrying capacity of streams for rearing juvenile salmonids. Because Chinook Salmon rear in streams for up to 3 years, they are vulnerable to heat stress during low flow periods of late summer and fall. However, the life history diversity of this species (particularly the diversity in age at maturity) likely enhances resilience to mortality events such as extreme flows or temperatures. The variation in sensitivity among Chinook Salmon populations and life histories is difficult to predict. Upriver populations are potentially more sensitive to water temperature and/or low flows because of their increased cumulative exposure to thermal stress and the higher

FISH						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						metabolic demands of a longer migration. However, these populations are likely better adapted to deal with thermal and energetic stress compared to lower Columbia River populations. For example, lower river populations (particularly ocean-type/fall run stocks) have lower energy stores and may be just as vulnerable to temperature-induced increases in metabolic costs as are upriver populations. In terms of run timing, stream- and ocean-type life histories (i.e. spring and fall runs, respectively) each have their own unique sensitivities to temperature. Stream-type fish rear longer in freshwater, and thus have greater cumulative exposure to potential water temperature-related stressors in tributary streams. However, ocean-type individuals migrate to sea at a smaller size (typically age-zero fry) and may be more vulnerable to any energetic impacts of warmer temperatures in lower rivers and estuaries. As adults, stream-type individuals migrate during the cooler months of the year in spring and then reside upriver before spawning in the fall; whereas ocean-type fish migrate during the warmest part of the year in late summer and fall, but spawn immediately afterward and therefore spend much less time running negative energy budgets in freshwater. Thus stream-type adults are relatively more vulnerable to heat stress and energy demands during summer residence, whereas ocean-type adults are more vulnerable to stress during migration itself. Assessing how each life history has responded to contemporary variation in climate is challenging because of confounding factors: stream-type populations are located higher in river systems and have been heavily affected by their increased cumulative exposure to dams Flow regimes: Low flows during the summer and fall may be stressful for migrating adults. Mass mortality events in both fall and spring-run Chinook Salmon have been linked to high temperatures due to low flows. Some salmon populations may also depend on high flows to allow passage to upstream spawning areas. For example, spring-run (stream-type) Chinook often migrate to spawning grounds during the high flows that occur from late-winter through early-summer. However, high flow events during the fall and winter can scour the gravels where embryos incubate, reducing egg-to-fry survival. Increased severity of winter

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Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						floods has been linked to decreased egg-to-fry survival in Washington. Snowmelt and the resulting runoff in spring may be important for aiding the seaward migration of salmon smolts. Reduced flows during the spring have both direct and indirect effects on smolt migrations. The reduced stream velocities increase the travel time required for smolts to reach the ocean–this in turn increases the time of exposure to predators. Low flows may also make smolts more vulnerable to predators per unit of time exposed. With warming, species such as Smallmouth Bass, Walleye, and Northern Pikeminnow will almost certainly become more effective predators on salmon smolts. Spring-run Chinook are particularly vulnerable to predation because they originate higher in river networks and have longer migrations to sea. However, although fall-run Chinook have shorter seaward migrations, many populations emigrate as age-zero fry, which makes them vulnerable to broader size-spectra of predators, likely increasing their predation risk per unit time of migration. Marine: Increases in ocean and estuarine temperature, increased stratification of the water column, and/or changes in the intensity and timing of coastal upwelling may alter primary and secondary productivity, with potential impacts on growth, productivity, survival, and migrations of salmonids. For example, cool Pacific-Decadal Oscillation (PDO) years have historically coincided with high returns of Chinook Salmon, while warm PDO cycles coincided with declines in salmon numbers. In general, changes in coastal ocean habitat quality and productivity could negatively impact Chinook Salmon.
Lower Columbia Coho ESU	Moderate-High	High	Moderate-High	Moderate-High	> Increased water temperatures (freshwater and sea surface) > Lower summer	In general, Coho Salmon likely exhibit sensitivity to warmer water temperatures (freshwater and ocean) and lower summer flows. Freshwater temperature and flow regimes: Central California represents the southern extent of the range for Coho Salmon, suggesting that they may be less sensitive to increases in water temperature than other species of Pacific Salmon (i.e. pink, chum, and sockeye). However, due to their reliance on streams for freshwater rearing, Coho are likely

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					flows	sensitive to both altered flow and thermal regimes. Juveniles prefer low-velocity habitat often in off-channel areas; reduced summer flows may increase the likelihood that such off-channel habitats become inaccessible, thermally stressful, or hypoxic. Early run timing individuals might be more sensitive to fall flood events, which are projected to increase in Washington, and may also be more sensitive to warmer water temperatures and lower flows during peak migration timing (i.e. mid-August to September). Later run timing individuals should be less sensitive because they migrate as adults during cooler periods of the year and their embryos are not yet buried in the gravel during late fall flooding. However, late run individuals may be more likely to have embryos or recently emerged fry threatened by spring flooding that is predicted to increase in severity and frequency. In general, Coho Salmon populations may be less resilient to episodic mortality events caused by climate stressors, because they exhibit only moderate levels of life history diversity and do not have as much variation in age at maturity as do Sockeye Salmon and Chinook Salmon. Marine: Increases in ocean and estuarine temperature, increased stratification of the water column, and/or changes in the intensity and timing of coastal upwelling may alter primary and secondary productivity, with potential impacts on growth, productivity, survival, and migrations of salmonids. For example, cool Pacific-Decadal Oscillation (PDO) years have historically coincided with high returns of Coho Salmon, while warm PDO cycles coincided with declines in salmon numbers. Cooler SSTs during the winter prior to and after smolt migration have also been linked to higher Coho survival. In general, changes in coastal ocean habitat quality and productivity could negatively impact Coho Salmon.
Lower Columbia Steelhead DPS	Moderate-High	High	Moderate-High	Moderate-High	> Altered spring runoff timing and amount/mag	The survival of Steelhead embryos or recently emerged fry may be sensitive to the timing and magnitude of spring runoff rather than the fall and winter aspects of flow regimes. For example, high winter flows that threaten the egg-to-fry survival of fall-spawning salmonids are not

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Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
					nitude > Increased water temperatures > Lower summer flows	predicted to negatively affect Steelhead. Steelhead may also exhibit some sensitivity to warming water temperatures. Direct measures of Oncorhynchus mykiss thermal physiology suggest many parameters do not differ significantly from those of other salmonids (except in locally adapted populations of Redband Rainbow Trout in desert streams). In addition, contemporary temperature regimes in the Columbia River cause Steelhead and Chinook Salmon to use the same thermal refuges during spawning migrations. Similar to Chinook Salmon, steelhead are vulnerable to high angling pressure when seeking refuge in cold refugia such as tributary junctions; thus warmer temperatures can have indirect effects on mortality. However, the geographic distribution of steelhead suggests they may be less sensitive to warm temperatures than other anadromous salmonids—Steelhead occur in Southern California, farther south than any Pacific Salmon. Further, the resident life history form of steelhead can persist in desert streams that often exceed 68˚F through what appears to be local adaptation. Whether steelhead populations from warmer streams exhibit higher thermal tolerance is poorly understood, as is the potential rate of evolution in attributes of thermal physiology. Similar to Chinook Salmon, steelhead exhibit alternative life histories in regards to run-timing, which confer different sensitivities to climate. Summer-run Steelhead migrate higher in river networks, entering freshwater between late spring and fall, and overwinter before spawning the following spring. In contrast, winter-run Steelhead migrate during winter or early spring and spawn immediately. Because they spend more time in freshwater, summer-run populations of Steelhead may be more sensitive to changes in flow and temperature regimes across river networks. For example, higher temperatures will increase the metabolic costs accrued by summer-run Steelhead during the several months that they hold in streams prior to spawning. The existence of a resident life history form likely buffers Steelhead

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						from environmental stochasticity and may make populations less vulnerable to extirpation. For example, anadromous individuals can survive ephemeral periods of unsuitability in their natal streams while they are away at the ocean, whereas residents can survive in years where conditions are poor along migratory routes.
Margined Sculpin	Moderate	Low	Low-Moderate	Moderate-High	> Increased water temperatures	Little information is available regarding the sensitivity of Margined Sculpin to climate change. Margined Sculpin likely prefer aquatic habitat with water temperatures below 68°F; they can withstand short exposure to 77°F water temperatures, but experience mortality at and above 80°F. Margined Sculpin are largely associated with pools and deeper habitats, although more recent studies indicate they may exhibit broader habitat usage than previously thought. However, a limited distribution (they are found in only a few drainages in Washington) likely limits their ability to move in response to climate change and human land use impacts (e.g. sedimentation, channelization, and water pollution related to logging, agriculture, development, and grazing).
Middle Columbia Steelhead DPS	Moderate-High	High	Moderate-High	Moderate	> Altered spring runoff timing and amount/magnitude > Increased water temperatures > Lower summer flows	The survival of Steelhead embryos or recently emerged fry may be sensitive to the timing and magnitude of spring runoff rather than the fall and winter aspects of flow regimes. For example, high winter flows that threaten the egg-to-fry survival of fall-spawning salmonids are not predicted to negatively affect steelhead. Steelhead may also exhibit some sensitivity to warming water temperatures. Direct measures of *Steelhead* thermal physiology suggest many parameters do not differ significantly from those of other salmonids (except in locally adapted populations of Redband Rainbow Trout in desert streams). In addition, contemporary temperature regimes in the Columbia River cause steelhead and Chinook Salmon to use the same thermal refuges during spawning migrations. Similar to Chinook Salmon, steelhead are vulnerable to high angling pressure when seeking refuge in cold refugia such as tributary junctions; thus warmer temperatures can have indirect effects on mortality. However, the geographic distribution of steelhead suggests they may be less sensitive to warm temperatures than other anadromous salmonids—Steelhead occur in Southern California, farther south than any Pacific

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Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						Salmon. Further, the resident life history form of Steelhead can persist in desert streams that often exceed 68˚F through what appears to be local adaptation. Whether Steelhead populations from warmer streams exhibit higher thermal tolerance is poorly understood, as is the potential rate of evolution in attributes of thermal physiology. Similar to Chinook Salmon, steelhead exhibit alternative life histories in regards to run-timing, which confer different sensitivities to climate. Summer-run Steelhead migrate higher in river networks, entering freshwater between late spring and fall, and overwinter before spawning the following spring. In contrast, winter-run Steelhead migrate during winter or early spring and spawn immediately. Because they spend more time in freshwater, summer-run populations of Steelhead may be more sensitive to changes in flow and temperature regimes across river networks. For example, higher temperatures will increase the metabolic costs accrued by summer-run Steelhead during the several months that they hold in streams prior to spawning. The existence of a resident life history form likely buffers Steelhead from environmental stochasticity and may make populations less vulnerable to extirpation. For example, anadromous individuals can survive ephemeral periods of unsuitability in their natal streams while they are away at the ocean, whereas residents can survive in years where conditions are poor along migratory routes.
Mountain Sucker	Low-Moderate	Low	Low-Moderate	Moderate	> Increased water temperatures > Altered flow regimes	Little information is available regarding the sensitivity of Mountain Sucker to climate change. Spawning typically occurs during mid- to late-summer during stable low flows and in water temperatures between 52-66°F. Warming water temperatures may affect spawning timing and other physiological and life history components of Mountain Sucker, including length of egg incubation. Floods, droughts, and altered streamflow volume likely impact egg and juvenile survival, availability of spawning habitat, and/or food availability (i.e. algae). Wildfires and resultant effects on stream temperatures, turbidity, and flow volumes may affect the quality and availability of mountain sucker habitat, but further information is needed.

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Olympic Mudminnow	Moderate	Low	Moderate	Moderate	> Increased high flood events	Olympic Mudminnows occupy slow-moving streams, ponds, and freshwater wetlands at lower elevations with minimal water flow and ample aquatic vegetation. This species appears to be fairly tolerant of temperature and oxygen fluctuations, but has been documented to seek out cooler water temperatures and shaded areas during summer temperature peaks. Relative intolerance of swift water limits Olympic Mudminnow distribution to lowland areas, and in combination with salinity intolerance, may make them vulnerable to sea level rise and saltwater intrusion in current wetland habitat, although no studies examining this risk have been conducted. This species is likely to be sensitive to any hydrological shifts (e.g. low flows, flood timing and magnitude, altered sediment delivery) that affect freshwater wetland availability, function, and composition.
Ozette Sockeye ESU	Moderate	Low	Moderate	Moderate	> Increased water temperatures (freshwater and sea surface) > Increased winter/spring flood events	In general, sockeye salmon likely exhibit sensitivity to warmer water temperatures (freshwater and sea surface) and increased severity or frequency of winter/spring flood events. Washington is near the southern extent of the range for Sockeye Salmon, suggesting that they will be sensitive to increases in water temperature (freshwater and ocean). For example, even at the northern extent of their range in Alaska, sockeye salmon in shallow, non-stratified lakes may be thermally stressed in the summer. In Washington, Sockeye generally rear in deep, thermally stratified lakes and can move below the thermocline if surface waters become thermally unsuitable. This suggests that Sockeye may be less sensitive to temperature during the freshwater phase of their life history, as they are able to behaviorally thermoregulate. Additionally, sockeye may be somewhat more buffered from metabolic stresses associated with warmer water temperatures because lake food webs are generally more productive than that of streams. In general, Pacific salmon survival is positively related to sea surface temperatures (SST) at the northern extent of their distribution, and negatively related at the southern extent. Indeed, recent research suggests that survival rates of sockeye salmon are strongly affected by variations in regional SST during early ocean life, with lower survival rates during years with warm SST anomalies (however, the mechanisms driving this trend may be upwelling and marine productivity rather than temperature per se).

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						Increases in ocean and estuarine temperature, increased stratification of the water column, and/or changes in the intensity and timing of coastal upwelling may alter primary and secondary productivity, with potential impacts on growth, productivity, survival, and migrations of salmonids. Sockeye Salmon are also likely sensitive to winter flood events that can scour substrates or move gravel and silts to bury embryos. Increased severity of winter floods has been linked to decreased egg-to-fry survival in fall-spawning Pacific salmon of Washington.
Pacific Cod (Salish Sea population)	High	High	High	Moderate-High	> Increased ocean temperatures	Though limited information is available regarding the sensitivity of the Salish Sea population of Pacific Cod to climate change, their main sensitivity will be due to potential increases in sea surface temperature. Pacific Cod spawning and recruitment are strongly linked to temperature, with colder water supporting larger hatch size and maximizing growth performance. Cooler waters also support higher abundance of zooplankton prey (e.g. copepods), which is thought to be linked to increased recruitment. Temperature over 45°F appear to be associated with poor spawning success and limited recruitment. For Atlantic Cod, declines in recruitment with increasing temperature were particularly high for cod at the limits of their distribution. Pacific Cod in Washington are already at the upper end of their thermal preference, which is likely to increase their sensitivity to any increases in temperature and could lead to northward population shifts.
Pacific Hake (Georgia Basin DPS)	Low-Moderate	Moderate	Low-Moderate	Moderate	> Increased ocean temperatures > Altered upwelling patterns	Pacific Hake are unlikely to experience direct physiological sensitivity to climate change. However, increases in sea surface temperature, changes in upwelling patterns, and the associated changes that these trigger in zooplankton abundance will increase their sensitivity. Pacific Hake have already been documented as moving northward into Canadian waters; this shift is thought to be linked to higher food abundance in more northerly waters. Pacific Hake primarily target euphausiids, which often decline in abundance with warmer water conditions. Potential increases in water temperature could lead to decreases in euphausiid prey, declines in recruitment, and further northward shifts of Pacific Hake.
Pacific Herring (Georgia Basin	Moderate-High	High	Moderate	Moderate-High	> Increased ocean	A main way in which Pacific Herring will be sensitive to climate change is through change in their prey availability and the distribution of

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DPS)					temperatures > Altered upwelling patterns > Changes in salinity > Saltwater intrusion in estuarine habitat	appropriate spawning habitat. Primary and secondary productivity are strongly linked to juvenile abundance, as juveniles tend to prey on zooplankton (e.g. copepods). Predicted increases in sea surface temperature and changes in upwelling, such as delayed and shorter upwelling seasons, could affect the timing and abundance of available prey for juveniles, though the magnitude of these effects is uncertain. In Washington, Pacific Herring populations have already shown northward movement for spawning and smaller juvenile cohorts, and these patterns could increase with predicted increases in sea surface temperature. Increased temperatures could also lead to northward shifts and increased abundance of Pacific Hake, which prey upon Pacific Herring and could thus lead to population declines through increased predation. Pacific Herring will also be sensitive to potential changes in nearshore and estuarine spawning habitat, such as increased salinity due to sea level rise and saltwater intrusion in estuaries, which could create suboptimal conditions for spawning and larval growth. Additionally, the suite of vegetative species used by this species as spawning substrate could change with long-term variation in water temperature and acidity. The prevalence and composition of this algal mat could result in degradation of spawning habitat to a degree that ultimately reduces incubation success.
Pacific Lamprey	Moderate-High	Moderate	Moderate-High	Moderate-High	> Increased water temperatures > Lower summer/fall flows > Increased winter flood events > Altered fire regimes	Pacific Lamprey exhibit physiological sensitivity to warming water temperatures. Egg and ammocoete survival is lowest and larval deformations most common at 72°F relative to lower water temperatures. Warmer summer water temperatures (>68°F) have also been found to compound adult body size reductions and accelerate sexual maturation and post-spawning death the following spring. All life stages of Pacific Lamprey are likely vulnerable to shifting flow regimes due to reduced snowpack, earlier snowmelt, and shifting precipitation regimes. Warmer water temperatures and low summer and fall flows can affect adult spawning migration timing (i.e. migration occurs earlier in warmer, lower flow years) and/or inhibit adult migrations upriver by constricting channels or causing thermal barriers. Reduced streamflows can also limit or degrade floodplain habitat for spawning and rearing by elevating water temperatures and/or contributing to juvenile and nest

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						stranding and desiccation. Juvenile Pacific Lamprey, which occupy low velocity stream margins, and Pacific Lamprey nests, which are found in low gradient stream reaches, may also be vulnerable to scouring via winter flood events. Wildfire may also affect survival and rearing by reducing stream shading; high shade is correlated with higher Pacific Lamprey ammocoete abundance. Climate-driven changes in the marine environment may also affect Pacific Lamprey, but little is known about this part of their life stage.
Pacific Sand Lance	Moderate-High	Moderate	Moderate	Moderate-High	> Increased air and ocean temperatures > Decreased oxygen > Sea level rise > Increased coastal erosion	Though there is limited information regarding the sensitivity of Pacific Sand Lance to climate change, their sensitivity is likely to stem from climate-induced changes in their intertidal spawning habitat and changes in prey distribution and abundance. Increasing air and sea surface temperatures could lead to suboptimal sediment temperature and lower oxygen conditions in sediments where Pacific Sand Lance prefer to burrow, forcing them to emerge from the sediment and making them more susceptible to predation. Pacific Sand Lance tend to return to the same burrowing sediment habitat interannual, so changes in nearshore habitat (e.g. due to rising sea level or coastal erosion from increased storms) could limit burrowing and spawning habitat availability. Increasing sea surface temperature could also lead to declines and changes in distribution in zooplankton, limited prey availability for sand lance, and decreased recruitment.
Puget Sound Chinook Salmon ESU	Moderate-High	High	Moderate-High	Moderate-High	> Increased freshwater temperatures > Lower summer flows > Increased winter/spring flood events	In general, Chinook Salmon appear sensitive to warmer water temperatures, low flows, and high flows. Warmer water temperatures can affect physiological performance and energy budgets, as well as developmental rates and the timing of key lifecycle transitions (i.e. phenology). Lower stream flows have been linked to mass mortality events of Chinook Salmon. Extreme high flows can reduce the likelihood of egg survival during incubation, and both low and high flows can affect adult migration. Temperature: Chinook Salmon appear sensitive to elevated freshwater temperatures both as juveniles rearing in tributary streams and as adults migrating up river networks to spawn. Water temperatures positively affect metabolic costs, so warming reduces the amount of

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						time a spawning adult can persist in freshwater and decreases the total distance a fish can migrate on a given level of energy stores. Indeed, Chinook Salmon that migrate slower, and accrue more energy loss, have higher mortality rates in the Columbia River. In addition to energetic effects, temperatures in excess of ~63˚F (the approximate temperature at which the maximum rate of physiological processes is observed for Chinook Salmon) begin to thermally stress individuals, making them more vulnerable to pathogens and other health issues. Episodes of high water temperature have led to large mortality events in several river systems within or adjacent to the Columbia River Basin. Puget Sound Chinook Salmon may be more sensitive to warmer summer temperatures and lower flows, as their spawning migration encounters the warmest part of the watershed (the downstream portion) during the warmer part of the year (later summer and early fall). Cool tributaries may provide refuge from heat stress for migratory Chinook Salmon, and may reduce the sensitivity of this species to warming temperatures. Warming temperatures in the streams where Chinook Salmon rear can have negative effects even when temperatures are not near the thermal maxima of the species. For example, the strength of density dependence in fish growth was positively related to water temperature, which corroborates the mechanistic predictions of bioenergetics models. This suggests warming temperatures decrease the carrying capacity of streams for rearing juvenile salmonids. Because Puget Sound Chinook Salmon rear in streams for up to 1 year, they may be vulnerable to heat stress during low flow periods of late summer and fall. However, the life history diversity of this species (particularly the diversity in age at maturity) likely enhances resilience to mortality events such as extreme flows or temperatures. Flow regimes: Low flows during the summer and fall may be stressful for migrating adults. Mass mortality events in both fall and spring-run Chinook Salmon have been linked to high temperatures due to low flows. Some salmon populations may also depend on high flows to allow passage to upstream spawning areas. For example, spring-run (stream-

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						type) Chinook often migrate to spawning grounds during the high flows that occur from late-winter through early-summer. However, high flow events during the fall and winter can scour the gravels where embryos incubate, reducing egg-to-fry survival. Increased severity of winter floods has been linked to decreased egg-to-fry survival in Washington. Snowmelt and the resulting runoff in spring may be important for aiding the seaward migration of salmon smolts. Reduced flows during the spring have both direct and indirect effects on smolt migrations. Marine: Increases in ocean and estuarine temperature, increased stratification of the water column, and/or changes in the intensity and timing of coastal upwelling may alter primary and secondary productivity, with potential impacts on growth, productivity, survival, and migrations of salmonids. For example, cool Pacific-Decadal Oscillation (PDO) years have historically coincided with high returns of Chinook Salmon, while warm PDO cycles coincided with declines in salmon numbers. In general, changes in coastal ocean habitat quality and productivity could negatively impact Chinook Salmon.
Puget Sound Steelhead DPS	Moderate-High	High	Moderate-High	Moderate-High	> Altered spring runoff timing and amount/magnitude > Increased water temperatures > Increased flood events and associated sedimentation and/or scour > Lower summer	In general, Steelhead appear sensitive to warmer water temperatures, low flows, and high flows. Warmer water temperatures can affect physiological performance and energy budgets, as well as developmental rates and the timing of key lifecycle transitions (i.e. phenology). Lower stream flows (particularly summer and early fall) can reduce the probability of survival in rearing juveniles. Extreme high flows can reduce the likelihood of egg survival during incubation, and both low and high flows can affect adult migration. Steelhead may be able to shift the timing of a life stage transition to reduce the probability of exposure to changes in temperature or flow through phenotypic plasticity. Similar to Chinook Salmon, Steelhead exhibit alternative life histories in regards to run-timing, which confer different sensitivities to climate. Summer-run Steelhead migrate higher in river networks, entering freshwater between late spring and fall, and overwinter before spawning the following spring. In contrast, winter-run Steelhead migrate

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					flows	during winter or early spring and spawn immediately. Because they spend more time in freshwater, summer-run populations of steelhead may be more sensitive to changes in flow and temperature regimes across river networks. For example, higher temperatures will increase the metabolic costs accrued by summer-run steelhead during the several months that they hold in streams prior to spawning. The existence of a resident life history form likely buffers Steelhead from environmental stochasticity and may make populations less vulnerable to extirpation. For example, anadromous individuals can survive ephemeral periods of unsuitability in their natal streams while they are away at the ocean, whereas residents can survive in years where conditions are poor along migratory routes. Temperature: Steelhead may exhibit some sensitivity to warming water temperatures. Direct measures of steelhead thermal physiology suggest many parameters do not differ significantly from those of other salmonids (except in locally adapted populations of redband rainbow trout in desert streams). In addition, contemporary temperature regimes in the Columbia River cause steelhead and Chinook Salmon to use the same thermal refuges during spawning migrations. Similar to Chinook Salmon, Steelhead are vulnerable to high angling pressure when seeking refuge in cold refugia such as tributary junctions; thus warmer temperatures can have indirect effects on mortality. However, the geographic distribution of Steelhead suggests they may be less sensitive to warm temperatures than other anadromous salmonids—Steelhead occur in Southern California, farther south than any Pacific Salmon. Further, the resident life history form of *Steelhead* can persist in desert streams that often exceed 68˚C through what appears to be local adaptation. Whether Steelhead populations from warmer streams exhibit higher thermal tolerance is poorly understood, as is the potential rate of evolution in attributes of thermal physiology. Flow regimes: The survival of Steelhead embryos or recently emerged fry may be sensitive to the timing and magnitude of spring runoff rather

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Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						than the fall and winter aspects of flow regimes. For example, high winter flows that threaten the egg-to-fry survival of fall-spawning salmonids are not predicted to negatively affect Steelhead. Marine: Increases in ocean and estuarine temperature, increased stratification of the water column, and/or changes in the intensity and timing of coastal upwelling may alter primary and secondary productivity, with potential impacts on growth, productivity, survival, and migrations of salmonids.
Pygmy Whitefish	Low-Moderate	Low	Low-Moderate	Moderate	> Increased water temperatures > Altered fire regimes	Pygmy Whitefish occupy cool lakes and streams with temperatures below 50°F, and are likely adapted to cold and low-productivity environments (i.e. small size, early maturation), making them sensitive to increasing water temperatures. Warmer water temperatures may have direct physiological effects, allow upstream expansion of some populations (provided no barriers exist) and/or affect ecological interactions by expanding the range of potential predators or competitors. Wildfires that remove stream- or lakeside vegetation may exacerbate temperature increases and/or contribute to sedimentation, which can affect spawning habitat.
Quillback Rockfish	Moderate-High	Moderate	Moderate	Moderate-High	> Increased ocean temperatures > Sea level rise > Declines in pH > Decreased oxygen	The main sensitivity of Quillback Rockfish to climate change is likely to stem from changes to their prey base. Warmer ocean conditions could lead to decreases in prey (e.g. copepods for juveniles, larger crustaceans, small fish, and cephalopods for adults) for both juveniles and adults, prompting decreases in adult fecundity and juvenile survival. Additionally, nearshore habitat loss due to sea level rise could impact juvenile survival, as juveniles tend to use nearshore habitat as nursery and foraging area. Deepwater coral habitat, which many adult rockfish use, may also decrease due to acidification, further reducing available habitat. Decreased oxygen levels may have direct physiological effects on Quillback Rockfish, leading to higher levels of mortality across various life stages. Due to their long life cycles and generation times, adults may be able to persist through short term pulses of negative ocean conditions (e.g. years with warmer sea surface temperature), though conversely, their low productivity could make it difficult for populations to recover from climate-related declines.

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Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
Redstripe Rockfish	Moderate-High	Moderate	Moderate	Moderate-High	> Increased ocean temperatures > Sea level rise > Declines in pH > Decreased oxygen	The main sensitivity of Redstripe Rockfish to climate change is likely to stem from changes to their prey base. Warmer ocean conditions could lead to decreases in prey (e.g. copepods for juveniles, larger crustaceans, small fish, and cephalopods for adults) for both juveniles and adults, prompting decreases in adult fecundity and juvenile survival. Additionally, nearshore habitat loss due to sea level rise could impact juvenile survival, as juveniles tend to use nearshore habitat as nursery and foraging area. Deepwater coral habitat, which many adult rockfish use, may also decrease due to acidification, further reducing available habitat. Decreased oxygen levels may have direct physiological effects on Redstripe Rockfish, leading to higher levels of mortality across various life stages. Due to their long life cycles and generation times, adults may be able to persist through short term pulses of negative ocean conditions (e.g. years with warmer sea surface temperature), though conversely, their low productivity could make it difficult for populations to recover from climate-related declines.
River Lamprey	Moderate-High	Low	Moderate-High	Moderate	> Increased water temperatures (fresh and ocean) > Lower summer/fall flows > Increased winter flood events	Little is known about River Lamprey vulnerability to climate change (particularly in Washington), but they likely have similar vulnerability to Pacific Lamprey because they exhibit similar life history stages (spawning, rearing, and migration), although they typically occupy larger rivers at lower elevations. Rearing individuals may be vulnerable to shifts in flow regimes (e.g. desiccation or stranding due to low flows, enhanced scouring from high flows) and water quality (e.g. temperature increases), and adult River Lamprey may also be vulnerable to temperature and migration barriers resulting from reduced streamflows. Changes in the marine and estuarine environment that affect River Lamprey hosts (e.g. Pacific Herring, Surf Smelt) will likely affect the marine survival of this species.
Salish Sucker	Moderate-High	Moderate	Moderate	Moderate-High	> Lower summer flows > Increased high flood events (frequency	Salish Suckers occupy lakes and pools of headwater streams, spawn in riffles, and prefer long/deep pools with slower water velocities that are adjacent to shallow habitat with abundant vegetation (i.e. in-stream and over-stream cover). They are likely sensitive to climate-driven changes in habitat availability and quality. Declining summer and spring streamflows may affect pool length and depth, availability of spawning areas, and/or habitat connectivity. Altered riparian cover due to wildfire

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Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
					and magnitude) > Decreased oxygen	and land use changes can affect rearing habitat availability and quality and exacerbate increasing water temperatures. Altered flood frequencies or magnitudes may also affect this species, particularly if off-channel refugia is not available. Salish Suckers appear to be fairly tolerant of various water temperatures; spawning typically begins around 45-46°F, but has been documented in water temperatures up to 68°F. However, sublethal effects of warmer water temperatures are unknown (e.g. impacts on growth, fecundity, disease incidence). Hypoxic conditions are increasingly threatening this species, and are exacerbated by warmer water temperatures and streamflow reductions.
Snake River Spring/Summer Chinook Salmon ESU	Moderate-High	High	Moderate-High	Moderate-High	> Increased freshwater temperatures > Lower summer flows > Increased winter/spring flood events	In general, Chinook Salmon appear sensitive to warmer water temperatures, low flows, and high flows. Warmer water temperatures can affect physiological performance and energy budgets, as well as developmental rates and the timing of key lifecycle transitions (i.e. phenology). Lower stream flows have been linked to mass mortality events of Chinook Salmon. Extreme high flows can reduce the likelihood of egg survival during incubation, and both low and high flows can affect adult migration. Temperature: Chinook Salmon appear sensitive to elevated freshwater temperatures both as juveniles rearing in tributary streams and as adults migrating up river networks to spawn. Water temperatures positively affect metabolic costs, so warming reduces the amount of time a spawning adult can persist in freshwater and decreases the total distance a fish can migrate on a given level of energy stores. Indeed, Chinook Salmon that migrate slower, and accrue more energy loss, have higher mortality rates in the Columbia River. In addition to energetic effects, temperatures in excess of ~63˚F (the approximate temperature at which the maximum rate of physiological processes is observed for Chinook Salmon) begin to thermally stress individuals, making them more vulnerable to pathogens and other health issues. Episodes of high water temperature have led to large mortality events in several river systems within or adjacent to the Columbia River Basin. In the Columbia River, cool tributaries provide refuge from heat stress for migratory Chinook Salmon, and may reduce the sensitivity of this species to

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Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						warming temperatures. However, time spent in thermal refugia can come at a price, such as increased exposure to angling pressure, later arrival at spawning grounds, and other factors. Warming temperatures in the streams where Chinook Salmon rear can have negative effects even when temperatures are not near the thermal maxima of the species. For example, the strength of density dependence in fish growth was positively related to water temperature, which corroborates the mechanistic predictions of bioenergetics models. This suggests warming temperatures decrease the carrying capacity of streams for rearing juvenile salmonids. Because Chinook Salmon rear in streams for up to three years, they are vulnerable to heat stress during low flow periods of late summer and fall. However, the life history diversity of this species (particularly the diversity in age at maturity) likely enhances resilience to mortality events such as extreme flows or temperatures. The variation in sensitivity among Chinook Salmon populations and life histories is difficult to predict. Upriver populations are potentially more sensitive to water temperature and/or low flows because of their increased cumulative exposure to thermal stress and the higher metabolic demands of a longer migration. However, these populations are likely better adapted to deal with thermal and energetic stress compared to lower Columbia River populations. For example, lower river populations (particularly ocean-type/fall run stocks) have lower energy stores and may be just as vulnerable to temperature-induced increases in metabolic costs as are upriver populations. In terms of run timing, stream- and ocean-type life histories (i.e. spring and fall runs, respectively) each have their own unique sensitivities to temperature. Stream-type fish rear longer in freshwater, and thus have greater cumulative exposure to potential water temperature-related stressors in tributary streams. However, ocean-type individuals migrate to sea at a smaller size (typically age-zero fry) and may be more vulnerable to any energetic impacts of warmer temperatures in lower rivers and estuaries. As adults, stream-type individuals migrate during the cooler months of

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						the year in spring and then reside upriver before spawning in the fall; whereas ocean-type fish migrate during the warmest part of the year in late summer and fall, but spawn immediately afterward and therefore spend much less time running negative energy budgets in freshwater. Thus stream-type adults are relatively more vulnerable to heat stress and energy demands during summer residence, whereas ocean-type adults are more vulnerable to stress during migration itself. Assessing how each life history has responded to contemporary variation in climate is challenging because of confounding factors: stream-type populations are located higher in river systems and have been heavily affected by their increased cumulative exposure to dams Flow regimes: Low flows during the summer and fall may be stressful for migrating adults. Mass mortality events in both fall and spring-run Chinook Salmon have been linked to high temperatures due to low flows. Some salmon populations may also depend on high flows to allow passage to upstream spawning areas. For example, spring-run (stream-type) Chinook often migrate to spawning grounds during the high flows that occur from late-winter through early-summer. However, high flow events during the fall and winter can scour the gravels where embryos incubate, reducing egg-to-fry survival. Increased severity of winter floods has been linked to decreased egg-to-fry survival in Washington. Snowmelt and the resulting runoff in spring may be important for aiding the seaward migration of salmon smolts. Reduced flows during the spring have both direct and indirect effects on smolt migrations. The reduced stream velocities increase the travel time required for smolts to reach the ocean–this in turn increases the time of exposure to predators. Low flows may also make smolts more vulnerable to predators per unit of time exposed. With warming, species such as Smallmouth Bass, Walleye, and Northern Pikeminnow will almost certainly become more effective predators on salmon smolts. Spring-run Chinook are particularly vulnerable to predation because they originate higher in river networks and have longer migrations to sea. However, although fall-run Chinook have shorter seaward migrations, many

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Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						populations emigrate as age-zero fry, which makes them vulnerable to broader size-spectra of predators, likely increasing their predation risk per unit time of migration. Marine: Increases in ocean and estuarine temperature, increased stratification of the water column, and/or changes in the intensity and timing of coastal upwelling may alter primary and secondary productivity, with potential impacts on growth, productivity, survival, and migrations of salmonids. For example, cool Pacific-Decadal Oscillation (PDO) years have historically coincided with high returns of Chinook Salmon, while warm PDO cycles coincided with declines in salmon numbers. In general, changes in coastal ocean habitat quality and productivity could negatively impact Chinook Salmon.
Snake River Basin Steelhead DPS	Moderate-High	High	Moderate-High	Moderate-High	> Altered spring runoff timing and amount/magnitude > Increased water temperatures > Lower summer flows	In general, Steelhead appear sensitive to warmer water temperatures, low flows, and high flows. Warmer water temperatures can affect physiological performance and energy budgets, as well as developmental rates and the timing of key lifecycle transitions (i.e. phenology). Lower stream flows (particularly summer and early fall) can reduce the probability of survival in rearing juveniles. Extreme high flows can reduce the likelihood of egg survival during incubation, and both low and high flows can affect adult migration. Steelhead may be able to shift the timing of a life stage transition to reduce the probability of exposure to changes in temperature or flow through phenotypic plasticity. Similar to Chinook Salmon, Steelhead exhibit alternative life histories in regards to run-timing, which confer different sensitivities to climate. Summer-run Steelhead migrate higher in river networks, entering freshwater between late spring and fall, and overwinter before spawning the following spring. In contrast, winter-run Steelhead migrate during winter or early spring and spawn immediately. Because they spend more time in freshwater, summer-run populations of steelhead may be more sensitive to changes in flow and temperature regimes across river networks. For example, higher temperatures will increase the metabolic costs accrued by summer-run Steelhead during the

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Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						several months that they hold in streams prior to spawning. The existence of a resident life history form likely buffers steelhead from environmental stochasticity and may make populations less vulnerable to extirpation. For example, anadromous individuals can survive ephemeral periods of unsuitability in their natal streams while they are away at the ocean, whereas residents can survive in years where conditions are poor along migratory routes. Temperature: Steelhead may exhibit some sensitivity to warming water temperatures. Direct measures of Steelhead thermal physiology suggest many parameters do not differ significantly from those of other salmonids (except in locally adapted populations of Redband Rainbow Trout in desert streams). In addition, contemporary temperature regimes in the Columbia River cause steelhead and Chinook Salmon to use the same thermal refuges during spawning migrations. Similar to Chinook Salmon, Steelhead are vulnerable to high angling pressure when seeking refuge in cold refugia such as tributary junctions; thus warmer temperatures can have indirect effects on mortality. However, the geographic distribution of Steelhead suggests they may be less sensitive to warm temperatures than other anadromous salmonids—steelhead occur in Southern California, farther south than any Pacific salmon. Further, the resident life history form of steelhead can persist in desert streams that often exceed 68˚F through what appears to be local adaptation. Whether steelhead populations from warmer streams exhibit higher thermal tolerance is poorly understood, as is the potential rate of evolution in attributes of thermal physiology. Flow regimes: The survival of Steelhead embryos or recently emerged fry may be sensitive to the timing and magnitude of spring runoff rather than the fall and winter aspects of flow regimes. For example, high winter flows that threaten the egg-to-fry survival of fall-spawning salmonids are not predicted to negatively affect Steelhead. Marine: Increases in ocean and estuarine temperature, increased

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Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						stratification of the water column, and/or changes in the intensity and timing of coastal upwelling may alter primary and secondary productivity, with potential impacts on growth, productivity, survival, and migrations of salmonids.
Snake River Fall Chinook Salmon ESU	Moderate-High	High	Moderate-High	Moderate-High	> Increased freshwater temperatures > Lower summer flows > Increased winter/spring flood events	In general, Chinook Salmon appear sensitive to warmer water temperatures, low flows, and high flows. Warmer water temperatures can affect physiological performance and energy budgets, as well as developmental rates and the timing of key lifecycle transitions (i.e. phenology). Lower stream flows have been linked to mass mortality events of Chinook Salmon. Extreme high flows can reduce the likelihood of egg survival during incubation, and both low and high flows can affect adult migration. Temperature: Chinook Salmon appear sensitive to elevated freshwater temperatures both as juveniles rearing in tributary streams and as adults migrating up river networks to spawn. Water temperatures positively affect metabolic costs, so warming reduces the amount of time a spawning adult can persist in freshwater and decreases the total distance a fish can migrate on a given level of energy stores. Indeed, Chinook Salmon that migrate slower, and accrue more energy loss, have higher mortality rates in the Columbia River. In addition to energetic effects, temperatures in excess of ~63˚F (the approximate temperature at which the maximum rate of physiological processes is observed for Chinook Salmon) begin to thermally stress individuals, making them more vulnerable to pathogens and other health issues. Episodes of high water temperature have led to large mortality events in several river systems within or adjacent to the Columbia River Basin. In the Columbia River, cool tributaries provide refuge from heat stress for migratory Chinook Salmon, and may reduce the sensitivity of this species to warming temperatures. However, time spent in thermal refugia can come at a price, such as increased exposure to angling pressure, later arrival at spawning grounds, and other factors. Warming temperatures in the streams where Chinook Salmon rear can have negative effects even when temperatures are not near the thermal

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						maxima of the species. For example, the strength of density dependence in fish growth was positively related to water temperature, which corroborates the mechanistic predictions of bioenergetics models. This suggests warming temperatures decrease the carrying capacity of streams for rearing juvenile salmonids. Because Chinook Salmon rear in streams for up to three years, they are vulnerable to heat stress during low flow periods of late summer and fall. However, the life history diversity of this species (particularly the diversity in age at maturity) likely enhances resilience to mortality events such as extreme flows or temperatures. The variation in sensitivity among Chinook Salmon populations and life histories is difficult to predict. Upriver populations are potentially more sensitive to water temperature and/or low flows because of their increased cumulative exposure to thermal stress and the higher metabolic demands of a longer migration. However, these populations are likely better adapted to deal with thermal and energetic stress compared to lower Columbia River populations. For example, lower river populations (particularly ocean-type/fall run stocks) have lower energy stores and may be just as vulnerable to temperature-induced increases in metabolic costs as are upriver populations. In terms of run timing, stream- and ocean-type life histories (i.e. spring and fall runs, respectively) each have their own unique sensitivities to temperature. Stream-type fish rear longer in freshwater, and thus have greater cumulative exposure to potential water temperature-related stressors in tributary streams. However, ocean-type individuals migrate to sea at a smaller size (typically age-zero fry) and may be more vulnerable to any energetic impacts of warmer temperatures in lower rivers and estuaries. As adults, stream-type individuals migrate during the cooler months of the year in spring and then reside upriver before spawning in the fall; whereas ocean-type fish migrate during the warmest part of the year in late summer and fall, but spawn immediately afterward and therefore spend much less time running negative energy budgets in freshwater. Thus stream-type adults are relatively more vulnerable to heat stress and energy demands during summer residence, whereas ocean-type

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Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						adults are more vulnerable to stress during migration itself. Assessing how each life history has responded to contemporary variation in climate is challenging because of confounding factors: stream-type populations are located higher in river systems and have been heavily affected by their increased cumulative exposure to dams Flow regimes: Low flows during the summer and fall may be stressful for migrating adults. Mass mortality events in both fall and spring-run Chinook salmon have been linked to high temperatures due to low flows. Some salmon populations may also depend on high flows to allow passage to upstream spawning areas. For example, spring-run (stream-type) Chinook often migrate to spawning grounds during the high flows that occur from late-winter through early-summer. However, high flow events during the fall and winter can scour the gravels where embryos incubate, reducing egg-to-fry survival. Increased severity of winter floods has been linked to decreased egg-to-fry survival in Washington. Snowmelt and the resulting runoff in spring may be important for aiding the seaward migration of salmon smolts. Reduced flows during the spring have both direct and indirect effects on smolt migrations. The reduced stream velocities increase the travel time required for smolts to reach the ocean–this in turn increases the time of exposure to predators. Low flows may also make smolts more vulnerable to predators per unit of time exposed. With warming, species such as Smallmouth Bass, Walleye, and Northern Pikeminnow will almost certainly become more effective predators on salmon smolts. Spring-run Chinook are particularly vulnerable to predation because they originate higher in river networks and have longer migrations to sea. However, although fall-run Chinook have shorter seaward migrations, many populations emigrate as age-zero fry, which makes them vulnerable to broader size-spectra of predators, likely increasing their predation risk per unit time of migration. Marine: Increases in ocean and estuarine temperature, increased stratification of the water column, and/or changes in the intensity and

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Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						timing of coastal upwelling may alter primary and secondary productivity, with potential impacts on growth, productivity, survival, and migrations of salmonids. For example, cool Pacific-Decadal Oscillation (PDO) years have historically coincided with high returns of Chinook Salmon, while warm PDO cycles coincided with declines in salmon numbers. In general, changes in coastal ocean habitat quality and productivity could negatively impact Chinook Salmon.
Surf Smelt	Moderate-High	High	Moderate-High	Moderate-High	> Increased air temperatures > Altered upwelling patterns > Sea level rise > Increased storminess	The primary presumed threat to Surf Smelt as a result of climate change is a reduction in spawning habitat due to sea level rise, acting in concert with shoreline armoring – a situation known as the "coastal squeeze." Because Surf Smelt utilize intertidal beaches for spawning, and the backshores of these beaches tend to be armored with bulkheads and other structures, rising sea level will effectively eliminate these habitats. Surf Smelt may also experience some physiological sensitivity to climate change since warmer and drier beach conditions have been shown to lead to higher levels of egg mortality. Surf Smelt sensitivity will be increased by potential changes in zooplankton prey availability. Predicted delayed and shorter upwelling systems could affect the timing and abundance of prey and lead to declines in prey availability, particularly for juveniles, though the magnitude of these impacts is uncertain. Additionally, since Washington Surf Smelt tend to use a small number of beaches for spawning, changes in beach habitat due to sea level rise and stronger and increased storms could lead to declines in available spawning area.
Tiger Rockfish	Moderate-High	Moderate	Moderate	Moderate-High	> Increased ocean temperatures > Sea level rise > Declines in pH > Decreased oxygen	The main sensitivity of Tiger Rockfish to climate change is likely to stem from changes to their prey base. Warmer ocean conditions could lead to decreases in prey (e.g. zooplankton) for both juveniles and adults, prompting decreases in adult fecundity and juvenile survival. Additionally, nearshore habitat loss due to sea level rise could impact juvenile survival, as juveniles tend to use nearshore habitat as nursery and foraging area. Deepwater coral habitat, which many adult rockfish use, may also decrease due to acidification, further reducing available habitat. Decreased oxygen levels may have direct physiological effects on Tiger Rockfish, leading to higher levels of mortality across various life stages. Due to their long life cycles and generation times, adults may be

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Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						able to persist through short term pulses of negative ocean conditions (e.g. years with warmer sea surface temperature), though conversely, their low productivity could make it difficult for populations to recover from climate-related declines.
Tui Chub	Low-Moderate	Low	Low-Moderate	Moderate	> Increased water temperatures > Altered flow regimes > Altered fire regimes	Little information is available regarding the sensitivity of Tui Chub to climate change. Tui Chub inhabit lakes and slow-moving pools in riverine environments, spawning and rearing in shallow areas in spring and summer. Similar to other minnow species, they are likely sensitive to climate-driven shifts in rearing and spawning habitat near stream and lake margins (e.g. reduced habitat due to reduced spring/summer low flows or lake water levels caused by reduced snowpack, earlier snowmelt, shifting precipitation regimes and/or drought). Wildfire may also affect streamside vegetative cover and rearing habitat, as young Tui Chub are typically found close to shore in areas with heavy vegetation. Tui Chub are also likely sensitive to increasing water temperatures, as yearly spring temperature increases cue spawning timing.
Umatilla Dace	Moderate	Low	Low-Moderate	Moderate-High	> Lower stream flows	Little information is available regarding the sensitivity of Umatilla Dace to climate change. Umatilla Dace may benefit from increasing water temperatures, as they are currently restricted to warmer habitat areas (e.g. mainstem and downstream areas), preferring zones with slightly warmer water temperatures (64-68°F). They are also found in cooler habitats, although they may exhibit reduced mobility and retreat to interstitial spaces at cooler temperatures. Umatilla Dace is likely sensitive to reduced streamflows resulting from reduced snowpack, earlier snowmelt, and drought, particularly if streamflow declines are exacerbated by shifts in human water use. Juveniles and young-of-the-year occupy stream margins, making them vulnerable to stranding as streamflows decline.
Upper Columbia River Spring Chinook Salmon ESU	Moderate-High	High	Moderate-High	Moderate-High	> Increased freshwater temperatures > Lower summer flows > Increased	In general, Chinook Salmon appear sensitive to warmer water temperatures, low flows, and high flows. Warmer water temperatures can affect physiological performance and energy budgets, as well as developmental rates and the timing of key lifecycle transitions (i.e. phenology). Lower stream flows have been linked to mass mortality events of Chinook Salmon. Extreme high flows can reduce the likelihood of egg survival during incubation, and both low and high flows can affect

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Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
					winter/spring flood events	adult migration. Temperature: Chinook Salmon appear sensitive to elevated freshwater temperatures both as juveniles rearing in tributary streams and as adults migrating up river networks to spawn. Water temperatures positively affect metabolic costs, so warming reduces the amount of time a spawning adult can persist in freshwater and decreases the total distance a fish can migrate on a given level of energy stores. Indeed, Chinook Salmon that migrate slower, and accrue more energy loss, have higher mortality rates in the Columbia River. In addition to energetic effects, temperatures in excess of ~63˚F (the approximate temperature at which the maximum rate of physiological processes is observed for Chinook Salmon) begin to thermally stress individuals, making them more vulnerable to pathogens and other health issues. Episodes of high water temperature have led to large mortality events in several river systems within or adjacent to the Columbia River Basin. In the Columbia River, cool tributaries provide refuge from heat stress for migratory Chinook Salmon, and may reduce the sensitivity of this species to warming temperatures. However, time spent in thermal refugia can come at a price, such as increased exposure to angling pressure, later arrival at spawning grounds, and other factors. Warming temperatures in the streams where Chinook Salmon rear can have negative effects even when temperatures are not near the thermal maxima of the species. For example, the strength of density dependence in fish growth was positively related to water temperature, which corroborates the mechanistic predictions of bioenergetics models. This suggests warming temperatures decrease the carrying capacity of streams for rearing juvenile salmonids. Because Chinook Salmon rear in streams for up to three years, they are vulnerable to heat stress during low flow periods of late summer and fall. However, the life history diversity of this species (particularly the diversity in age at maturity) likely enhances resilience to mortality events such as extreme flows or temperatures.

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Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						The variation in sensitivity among Chinook Salmon populations and life histories is difficult to predict. Upriver populations are potentially more sensitive to water temperature and/or low flows because of their increased cumulative exposure to thermal stress and the higher metabolic demands of a longer migration. However, these populations are likely better adapted to deal with thermal and energetic stress compared to lower Columbia River populations. For example, lower river populations (particularly ocean-type/fall run stocks) have lower energy stores and may be just as vulnerable to temperature-induced increases in metabolic costs as are upriver populations. In terms of run timing, stream- and ocean-type life histories (i.e. spring and fall runs, respectively) each have their own unique sensitivities to temperature. Stream-type fish rear longer in freshwater, and thus have greater cumulative exposure to potential water temperature-related stressors in tributary streams. However, ocean-type individuals migrate to sea at a smaller size (typically age-zero fry) and may be more vulnerable to any energetic impacts of warmer temperatures in lower rivers and estuaries. As adults, stream-type individuals migrate during the cooler months of the year in spring and then reside upriver before spawning in the fall; whereas ocean-type fish migrate during the warmest part of the year in late summer and fall, but spawn immediately afterward and therefore spend much less time running negative energy budgets in freshwater. Thus stream-type adults are relatively more vulnerable to heat stress and energy demands during summer residence, whereas ocean-type adults are more vulnerable to stress during migration itself. Assessing how each life history has responded to contemporary variation in climate is challenging because of confounding factors: stream-type populations are located higher in river systems and have been heavily affected by their increased cumulative exposure to dams Flow regimes: Low flows during the summer and fall may be stressful for migrating adults. Mass mortality events in both fall and spring-run Chinook Salmon have been linked to high temperatures due to low flows. Some salmon populations may also depend on high flows to allow passage to upstream spawning areas. For example, spring-run (stream-

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Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						type) Chinook often migrate to spawning grounds during the high flows that occur from late-winter through early-summer. However, high flow events during the fall and winter can scour the gravels where embryos incubate, reducing egg-to-fry survival. Increased severity of winter floods has been linked to decreased egg-to-fry survival in Washington. Snowmelt and the resulting runoff in spring may be important for aiding the seaward migration of salmon smolts. Reduced flows during the spring have both direct and indirect effects on smolt migrations. The reduced stream velocities increase the travel time required for smolts to reach the ocean–this in turn increases the time of exposure to predators. Low flows may also make smolts more vulnerable to predators per unit of time exposed. With warming, species such as Smallmouth Bass, Walleye, and Northern Pikeminnow will almost certainly become more effective predators on salmon smolts. Spring-run Chinook are particularly vulnerable to predation because they originate higher in river networks and have longer migrations to sea. However, although fall-run Chinook have shorter seaward migrations, many populations emigrate as age-zero fry, which makes them vulnerable to broader size-spectra of predators, likely increasing their predation risk per unit time of migration. Marine: Increases in ocean and estuarine temperature, increased stratification of the water column, and/or changes in the intensity and timing of coastal upwelling may alter primary and secondary productivity, with potential impacts on growth, productivity, survival, and migrations of salmonids. For example, cool Pacific-Decadal Oscillation (PDO) years have historically coincided with high returns of Chinook Salmon, while warm PDO cycles coincided with declines in salmon numbers. In general, changes in coastal ocean habitat quality and productivity could negatively impact Chinook Salmon.
Upper Columbia Steelhead DPS	Moderate-High	High	Moderate-High	Moderate-High	> Altered spring runoff timing and amount/mag	The survival of Steelhead embryos or recently emerged fry may be sensitive to the timing and magnitude of spring runoff rather than the fall and winter aspects of flow regimes. For example, high winter flows that threaten the egg-to-fry survival of fall-spawning salmonids are not

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Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
					nitude > Increased water temperatures	predicted to negatively affect Steelhead. Steelhead may also exhibit some sensitivity to warming water temperatures. Direct measures of Steelhead thermal physiology suggest many parameters do not differ significantly from those of other salmonids (except in locally adapted populations of Redband Rainbow Trout in desert streams). In addition, contemporary temperature regimes in the Columbia River cause steelhead and Chinook Salmon to use the same thermal refuges during spawning migrations. Similar to Chinook Salmon, Steelhead are vulnerable to high angling pressure when seeking refuge in cold refugia such as tributary junctions; thus warmer temperatures can have indirect effects on mortality. However, the geographic distribution of Steelhead suggests they may be less sensitive to warm temperatures than other anadromous salmonids—Steelhead occur in Southern California, farther south than any Pacific salmon. Further, the resident life history form of steelhead can persist in desert streams that often exceed 68˚F through what appears to be local adaptation. Whether Steelhead populations from warmer streams exhibit higher thermal tolerance is poorly understood, as is the potential rate of evolution in attributes of thermal physiology. Similar to Chinook Salmon, steelhead exhibit alternative life histories in regards to run-timing, which confer different sensitivities to climate. Summer-run Steelhead migrate higher in river networks, entering freshwater between late spring and fall, and overwinter before spawning the following spring. In contrast, winter-run Steelhead migrate during winter or early spring and spawn immediately. Because they spend more time in freshwater, summer-run populations of steelhead may be more sensitive to changes in flow and temperature regimes across river networks. For example, higher temperatures will increase the metabolic costs accrued by summer-run steelhead during the several months that they hold in streams prior to spawning. The existence of a resident life history form likely buffers Steelhead from environmental stochasticity and may make populations less

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Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						vulnerable to extirpation. For example, anadromous individuals can survive ephemeral periods of unsuitability in their natal streams while they are away at the ocean, whereas residents can survive in years where conditions are poor along migratory routes.
Walleye Pollock (South Puget Sound)	Moderate	High	Moderate	Moderate	> Increased ocean temperatures	Walleye Pollock are likely to be sensitive to increases in sea surface temperature, particularly since Puget Sound is the southern limit of their range. Cooler waters support higher levels of Walleye Pollock recruitment and larval survival because cooler waters promote increased production of primary prey species for pollock (e.g. copepods, euphausiids, other zooplankton). For Walleye Pollock in the Bering Sea, it was found that though warmer spring conditions during spawning season enhanced early survival of larvae, continued higher temperatures led to poor feeding conditions and reduced recruitment the following year. Thus, predicted warming could result in decreases in prey abundance and declines in recruitment, larval survival, and productivity and potential northward range shifts of Walleye Pollock.
Westslope Cutthroat Trout	Low-Moderate	Low	Low-Moderate	Moderate	> Increased spring flood events > Altered runoff timing and amount > Increased water temperatures > Lower summer flows	Westslope Cutthroat Trout spawn in the spring and are thus sensitive to the timing and magnitude of snowmelt and the accompanying flood pulse. Winter floods do not pose a risk to Westslope Cutthroat Trout embryos, but it is possible that increased severity of fall and winter floods could negatively affect overwintering juveniles (although quality data on this topic are lacking due to the challenge of monitoring survival in flood prone systems). Like many stream rearing salmonids, Westslope Cutthroat Trout can be vulnerable to sub-optimally warm temperatures during base flow periods in late summer and fall. During these low flow periods, terrestrial subsidies typically comprise the dominant food source for this species, and may be critical for enabling fish to offset the elevated metabolic costs caused by higher water temperatures. Factors that mediate the magnitude of terrestrial subsidies, such as land use practices in riparian areas, can in turn mediate the sensitivity of trout to altered thermal regimes. Recruitment of Westslope Cutthroat Trout in high elevation streams

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Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						may be constrained by cold, rather than warm, summer temperatures. Warming may have some positive effects by increasing the amount of high elevation habitat capable of rearing juveniles. The primary source of decline for Westslope Cutthroat Trout has been hybridization with Rainbow Trout. A key uncertainty is how climate conditions might facilitate hybridization. Genetically pure Westslope Cutthroat Trout often exist in cold tributary streams and show subtle signs of being better adapted to cold temperatures than Rainbow Trout when studied in the laboratory. This suggests warming temperatures could increase hybridization by allowing Rainbow Trout to invade cold headwater streams. However, in an analysis across a large watershed, environmental factors were not as important as demographic factors in determining levels of hybridization. Westslope Cutthroat Trout are unique among the cutthroat subspecies in that they exhibit an anadromous, coastal-roaming ecotype. Populations with this life history may be less sensitive to altered flow and thermal regimes in freshwater because there is less cumulative exposure to freshwater conditions and individuals at sea can survive ephemeral climate-related disturbance such as thermal stress events or periods of low flow.
White Sturgeon (Columbia River)	Moderate	Low	Moderate	Moderate	> Increased water temperatures > Lower summer flows	White Sturgeon likely exhibit physiological sensitivity to warmer water temperatures, and increasing temperatures may reduce spawning success and/or increase disease risk and mortality. White Sturgeon are also sensitive to declining spring and summer streamflows, which reduce spawning habitat and annual recruitment; loss of spawning habitat and reduced recruitment associated with lower streamflows is a particular concern for impounded portions of the Columbia River. Shifts in ocean conditions may also affect prey availability for young White Sturgeon in estuarine environments, and reduced prey availability has been linked with undermined White Sturgeon growth.
Yelloweye Rockfish (Puget	Moderate-High	Moderate	Moderate	Moderate-High	> Increased ocean temperatures	The main sensitivity of Yelloweye Rockfish to climate change is likely to stem from changes to their prey base. Warmer ocean conditions could lead to decreases in prey (e.g. small fish, crabs, gastropods) for both

FISH						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
Sound/Georgia Basin DPS)					> Sea level rise > Declines in pH > Decreased oxygen	juveniles and adults, prompting decreases in adult fecundity and growth and juvenile survival. Additionally, nearshore habitat loss due to sea level rise could impact juvenile survival, as juveniles tend to use nearshore habitat as nursery and foraging area. Deepwater coral habitat, which is particularly preferred by Yelloweye Rockfish, may also decrease due to acidification, further reducing available habitat. Decreased oxygen levels may have direct physiological effects on Yelloweye Rockfish, leading to higher levels of mortality across various life stages. Due to their long life cycles and generation times, adults may be able to persist through short term pulses of negative ocean conditions (e.g. years with warmer sea surface temperature), though conversely, their low productivity could make it difficult for populations to recover from climate-related declines.

C.2.5 Invertebrate Vulnerability Rankings

INVERTEBRATES						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
A Caddisfly *(Allomyia Acanthis)*	High	Moderate	High	Moderate-High	> Increased air and water temperatures > Low summer flows > Increased sedimentation and erosion	*Allomyia Acanthis* is an uncommon species of caddisfly found in only a few locations in the Cascade regions of Washington and Oregon. Although little is known about this species, caddisflies in the genus *Allomyia* are restricted to high-elevation coldwater streams in the larval and pupae stages, where they build protective cases of silk and small pieces of rock. Climate sensitivity for this species is likely tied primarily to their specialized habitat, which is particularly vulnerable to warming air and water temperatures, low summer flows, sedimentation from upstream erosion, and habitat fragmentation from nearby human activity (i.e. forestry practices and road construction). Caddisflies in general are often considered an indicator of high-quality streams, suggesting that they are particularly vulnerable to changes in their habitat.
A Caddisfly *(Goereilla*	High	High	High	Moderate-High	> Increased air and water	*Goereilla Baumanni* is a species of caddisfly found only in few sites and always in very low numbers in Washington, Idaho, and Montana. They

INVERTEBRATES						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
Baumanni)					temperatures > Drought and/or changes in precipitation > Low summer flows > Increased sedimentation and erosion	are restricted to headwater springs and seepage in high-elevation forested areas during their larval and pupae stages, and within this habitat are associated with the surrounding muck comprised of decomposing organic materials. Sensitivity for this species is likely tied primarily to their specialized habitat, which is particularly vulnerable to warming air and water temperatures, low summer flows, sedimentation from upstream erosion, and habitat fragmentation from nearby human activity (i.e. forestry practices and road construction). The close association of *Goereilla Baumanni* to organic muck may make this species particularly sensitive to high temperatures, drought, and precipitation changes which may make these areas more likely to dry out. Caddisflies in general are often considered an indicator of high-quality streams, suggesting that they are particularly vulnerable to changes in their habitat.
A Caddisfly *(Limnephilus Flavastellus)*	Moderate-High	Low	Moderate	Moderate-High	> Increased air and water temperatures > Drought and/or changes in precipitation > Increased sedimentation and erosion	Little information is available on the caddisfly species *Limnephilus Flavastellus*, which can be found in mountainous areas of Washington, Oregon, and British Columbia. Their habitat can include coldwater ponds in forested areas, where they live in the water throughout their larval and pupae stages. This species is likely less sensitive than caddisflies that are restricted only to coldwater streams, as they can tolerate the slightly larger range of conditions found in ponds. Sensitivity for this species is likely tied primarily to their specialized habitat, which is vulnerable to warming air and water temperatures, drought and changing precipitation patterns, sedimentation from upstream erosion, and habitat fragmentation from nearby human activity (i.e. forestry practices and road construction). Caddisflies in general are often considered an indicator of high-quality streams, suggesting that they are may be vulnerable to changes in their habitat.
A Caddisfly *(Psychoglypha Browni)*	Moderate-High	Moderate	Moderate-High	Moderate-High	> Increased air and water temperatures > Drought and/or changes in precipitation	*Psychoglypha Browni* is an uncommon species of caddisfly found only in the Cascades region of Washington and Oregon. Little is known about this species, though the genus Psychoglypha is restricted to coldwater aquatic habitats such as streams, small rivers, and ponds in high-elevation forested areas. Sensitivity for this species is likely tied primarily to their specialized habitat, which is vulnerable to warming air and water temperatures, drought and changing precipitation patterns,

INVERTEBRATES						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
					> Low summer flows > Increased sedimentation and erosion	sedimentation from upstream erosion, and habitat fragmentation from nearby human activity (i.e. forestry practices and road construction). Caddisflies in general are often considered an indicator of high-quality streams, suggesting that they are may be vulnerable to changes in their habitat.
A Caddisfly *(Rhyacophila Pichaca)*	Moderate	Low	Moderate	Moderate	> Changes in precipitation > Drought > Low summer flows	*Rhyacophila Pichaca* is an uncommon species of caddisfly found in only a few locations in Washington and Oregon. Little is known about this species, but caddisflies in the genus *Rhyacophila* are fairly large and are free-living in their larval stage (i.e. they do not build cases until the pupae stage), making them particularly vulnerable to predation. All species in this genus are restricted to streams or rivers in the larval and pupae stages, though no information is available on whether this species is restricted to cold water or high-elevation areas. Given that they are dependent on running water, it is likely that drought, changes in precipitation patterns, and low summer flows contribute to this species' sensitivity. Caddisflies in general are often considered an indicator of high-quality streams, suggesting that they are may be vulnerable to changes in their habitat.
A Caddisfly *(Rhyacophila Vetina)*	High	Moderate	High	Moderate-High	> Increased air and water temperatures > Low summer flows > Increased sedimentation and erosion	Little information is available on *Rhyacophila Vetina*, an uncommon species of caddisfly reported in only a few high-elevation locations in the High Cascades region. Little is known about this species, but caddisflies in the genus *Rhyacophila* are fairly large and are free-living in their larval stage (i.e. they do not build cases until the pupae stage), making them particularly vulnerable to predation. All species in this genus are restricted to streams or rivers in the larval and pupae stages, and given that *Rhyacophila Vetina* only occurs in high-elevation streams, it is likely tied to coldwater conditions as well. Climate sensitivity for this species is likely tied primarily to this specialized habitat, which is particularly vulnerable to warming air and water temperatures, low summer flows, sedimentation from upstream erosion, and habitat fragmentation from nearby human activity (i.e. forestry practices and road construction). Caddisflies in general are often considered an indicator of high-quality streams, suggesting that they are particularly vulnerable to changes in their habitat.

INVERTEBRATES						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
A Mayfly *(Cinygmula Gartrelli)*	Low-Moderate	Low	Low-Moderate	Moderate	> Increased water temperatures > Changes in precipitation and/or drought > Low summer flows	Little is known about *Cinygmula Gartrelli*, a species of mayfly which has been located in California, Oregon, Washington, Montana, and British Columbia. All mayflies require aquatic habitats for nymph survival, and this species was located in a river in at least one of the records. Sensitivity likely is tied to this requirement, and the species could be affected by drought, precipitation changes, and summer low flows. Mayflies tend to be sensitive to changes in streambed substrate, water temperature, and water quality as well.
A Mayfly *(Paraleptophle bia Falcula)*	Low-Moderate	Low	Low-Moderate	Moderate	> Increased water temperatures > Changes in precipitation and/or drought > Low summer flows	Little is known about *Paraleptophle bia Falcula*, a species of mayfly which has been located in rivers in Washington, Oregon, and Idaho. All mayflies require aquatic habitats for nymph survival, so sensitivity likely is tied to this requirement. This species could be affected by changes in hydrology including drought, precipitation changes, and summer low flows. Mayflies tend to be sensitive to changes in streambed substrate, water temperature, and water quality as well.
A Mayfly *(Paraleptophle bia Jenseni)*	Low-Moderate	Low	Low-Moderate	Moderate	> Increased water temperatures > Changes in precipitation and/or drought > Low summer flows	Little is known about *Paraleptophlebia Jenseni*, a species of mayfly which has been located in Washington and a single site in Idaho. All mayflies require aquatic habitats for nymph survival, so sensitivity likely is tied to this requirement. This species could be affected by changes in hydrology including drought, precipitation changes, and summer low flows. Mayflies tend to be sensitive to changes in streambed substrate, water temperature, and water quality as well.
A Mayfly *(Siphlonurus Autumnalis)*	Low	Low	Low	Low-Moderate	> Increased water temperatures > Changes in precipitation	*Siphlonarus Autumnalis* is found along medium and large rivers in the Pacific Northwest. It usually inhabits quiet edgewaters along the rivers, particularly in rocky areas. However, it has also been found along small spring brooks, floodplain ponds, and small lakes. Although, like all mayflies, S. Autumnalis requires aquatic habitats for nymph survival, the

INVERTEBRATES						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
					and/or drought > Low summer flows	wide range of habitats in which it can survive decreases the vulnerability of this species. Sensitivity is likely tied to changes in the hydrology of these aquatic habitats, including drought, precipitation changes, and summer low flows. Mayflies tend to be sensitive to changes in streambed substrate, water temperature, and water quality as well.
A Noctuid Moth *(Copablepharon Columbia)*	Moderate	Low	Low-Moderate	Moderate-High	> Changes in precipitation and/or drought > Increased invasive species	There is limited information on the sensitivity of *Copablepharon Columbia* to climate change. This species occupies open (i.e., active) Columbia Basin sand dune habitats, but has been observed at only one dune site. This species is likely sensitive to sand dune stabilization, which typically leads to a loss of native vegetation and prevents formation of new dune areas. Sand dune stabilization is enhanced by high plant cover, which is facilitated during years of high precipitation and may also occur as a result of longer growing seasons due to climate change. Invasive species can also increase rates of dune stabilization. Drought may favor higher dune activity, which could enhance habitat quality and/or increase overall habitat for this moth, but could also impact its food plants (unknown at this time). For more information on habitat sensitivity, see Inter-Mountain Basins Active and Stabilized Dune habitat assessment.
A Noctuid Moth *(Copablepharon Mutans)*	Moderate	Low	Low-Moderate	Moderate-High	> Changes in precipitation and/or drought > Increased invasive species	There is limited information on the sensitivity of *Copablepharon Mutans* to climate change. Similar to *Copablepharon Columbia*, it is likely sensitive to sand dune stabilization which typically leads to a loss of native vegetation and prevents formation of new dune areas. Sand dune stabilization is enhanced by high plant cover, which is facilitated during years of high precipitation and may also occur as a result of longer growing seasons due to climate change. Invasive species can also increase rates of dune stabilization. Drought may favor higher dune activity, which could enhance habitat quality and/or increase overall habitat for this moth, but could also impact its food plants (unknown at this time). For more information on habitat sensitivity, see Inter-Mountain Basins Active and Stabilized Dune habitat assessment.
A Noctuid Moth *(Copablepharon Viridisparsa*	Moderate	Low	Low-Moderate	Moderate-High	> Changes in precipitation and/or drought	There is limited information on the sensitivity of *Copablepharon Viridisparsa Hopfingeri* to climate change. Similar to *Copablepharon Columbia*, it is likely sensitive to sand dune stabilization which typically leads to a loss of native vegetation and prevents formation of new dune

INVERTEBRATES						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
Hopfingeri)					> Increased invasive species	areas. Sand dune stabilization is enhanced by high plant cover, which is facilitated during years of high precipitation and may also occur as a result of longer growing seasons due to climate change. Invasive species can also increase rates of dune stabilization. Drought may favor higher dune activity, which could enhance habitat quality and/or increase overall habitat for this moth, but could also impact its food plants (unknown at this time). For more information on habitat sensitivity, see Inter-Mountain Basins Active and Stabilized Dune habitat assessment.
Ashy Pebblesnail	Moderate	Low	Low-Moderate	Moderate-High	> Altered flow regimes > Reduced oxygen > Increased water temperatures	There is limited information on the sensitivity of the Ashy Pebblesnail to climate change. This species displays very similar traits and habitat requirements to the Olympia Pebblesnail. The Ashy Pebblesnail's habitat range is believed to be restricted to the Columbia River Basin's rivers, streams, and creeks, although its historic range encompassed Washington, Oregon, and Idaho. The Ashy Pebblesnail requires clear, cold, highly oxygenated streams, and therefore may be sensitive to changes in flow regimes and increases in water temperature that negatively impact dissolved oxygen levels and chemical and biological processes. Changes in flow regimes that increase nutrient runoff may cause dense algae blooms that impair or prevent the Ashy Pebblesnail's access to important food resources (e.g., lithophytes). The invasive New Zealand Mudsnail (*Potamopyrgus Antipodarum*) may be a direct competitor for food and habitat.
Barren Juga	Moderate-High	Low	Moderate-High	Moderate-High	> Altered flow regimes > Reduced oxygen > Increased water temperatures	There is limited information on the sensitivity of this species to climate change. The Barren Juga's habitat range includes small- to medium-sized creeks and low elevation springs in the Columbia River Gorge area. This species requires cold, highly oxygenated water, and therefore may be sensitive to changes in flow regimes and increases in water temperature that negatively impact dissolved oxygen levels and chemical and biological processes.
Beller's Ground Beetle	Moderate-High	`	Moderate	Moderate-High	> Changes in precipitation (snow and rain) > Increased amount	Beller's Ground Beetle inhabits sphagnum bogs or sphagnum moss in other wet areas (e.g., near springs), preferring the wettest sites available. This species' sensitivity to climate change will largely be driven by shifts in habitat availability. Reduced water availability and quality (i.e., due to precipitation shifts, reduced snowpack, earlier snowmelt) can affect bog water levels, seasonal bog duration, and rates of

INVERTEBRATES						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
					and/or duration of flooding > Drought	succession to meadow or other adjacent vegetation, potentially reducing or degrading habitat for this beetle. This species is likely sensitive to both bog drying and prolonged inundation from flooding. Without flight capabilities, this species has limited ability to move in response to climate change (i.e., refugia would have to be contiguous and accessible by ground). Warmer temperatures may increase beetle activity; Beller's Ground Beetles have historically been found in highest numbers during hot periods.
Bluegray Taildropper	Low-Moderate	Low	Low-Moderate	Moderate	> Increased temperatures > Reduced soil moisture and/or changes in precipitation > Altered fire regimes	There is limited information regarding the sensitivity of Bluegray Taildroppers to climate change. Their main sensitivity is likely to be driven by changes in their preferred habitat – older, late successional, forests with moist ground and a mixture of hardwood and conifer trees. Increases in temperature and decreases in summer rainfall are likely to lead to increased risk of severe fires, which would destroy habitat for this species. Declines in habitat quality could also lead to fragmentation of populations, particularly since slugs are not very mobile, and eventual population declines. Additionally, decreased summer rainfall and increased droughts could lead to changes in soil moisture and availability of fungal populations that this species feeds on.
Brown Juga	Moderate-High	Low	Moderate-High	Moderate	> Altered flow regimes > Reduced oxygen > Increased water temperatures	There is limited information on the sensitivity of this species to climate change. The Brown Juga's habitat includes shallow, small streams and springs. This species requires cold, highly oxygenated water, and therefore may be sensitive to changes in flow regimes and increases in water temperature that negatively impact dissolved oxygen levels and chemical and biological processes.
California Floater	Moderate	Low	Low-Moderate	Moderate-High	> Increased water temperatures > Altered flow regimes > Drought	There is limited information regarding the sensitivity of California Floaters to climate change. This species, which has already experienced significant declines over the past few decades, is generally found in shallow pools of freshwater streams and reservoirs with good water quality and a sufficient abundance of small fish who serve as hosts for mussels during their transition from the larval to juvenile stage. Therefore, their main sensitivity is likely to stem from climate-induced changes in water quality and host fish abundance. For instance,

INVERTEBRATES						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						increased intensity of winter storms could lead to higher flow in rivers and increased nutrient runoff, both of which would degrade and reduce available mussel habitat. Additionally, increases in water temperature could lead to altered abundance of host fish for larval stage mussels, thus leading to declines in abundance. This species may also be sensitive to summer droughts, which could lead to shallower water levels in the pools that serve as mussel habitat, and potential air exposure and mortality, particularly since mussels have limited mobility and thus limited ability to respond to changes in habitat.
Cascades Needlefly	Moderate-High	Low	Moderate-High	Moderate	> Increased water temperatures > Changes in precipitation and/or drought > Altered flow regimes	The Cascades Needlefly is a rare species limited to very few sites in Washington, Oregon, Idaho, and Montana. The larvae are restricted to seeps, springs, and spring-fed streams, and the genus *Megaleuctra* is dependent on coldwater habitats that do not dry out, as well as high water quality. The sensitivity of this species is likely closely tied to their specialized habitat requirements. Changes in flow patterns due to drought or changing patterns of precipitation, changes in water temperature, and decreased water quality are all likely to increase the sensitivity of the species. Habitat fragmentation and nearby development also alter the quality and availability of suitable habitat.
Chelan Mountainsnail	Low-Moderate	Low	Low	Moderate-High	> Altered fire regimes	There is limited information on the sensitivity of this species to climate change. The Chelan Mountainsnail is typically found in schist talus habitat and in detritus or under shrubs with pinegrass or elk sedge understory at elevations ranging from 1197 to 2625 feet. This species may exhibit sensitivity to disturbances including wildfire, landslides, and habitat alterations that may shift the temperature and moisture regimes of preferred habitat types.
Chinquapin Hairstreak	Moderate-High	Low	Moderate	Moderate-High	> Increased temperatures > Reduced soil moisture and/or changes in precipitation > Altered fire regimes	Climate sensitivity of this species is likely driven by temperature, moisture declines, and fire. Like most insects, butterfly emergence and activity is influenced by temperature, and warmer temperatures may enhance emergence timing and/or lengthen daily flight activity. This species may be sensitive to moisture declines, as it obtains salt from moist soil and recently dried puddles. Increasing fire frequency may affect distribution of golden chinquapin, the larval host plant for this species. Golden chinquapin is shade-intolerant and regenerates quickly after fire and other disturbance, and more frequent fires could

INVERTEBRATES						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						potentially increase chinquapin establishment opportunities and overall habitat for this butterfly. However, this butterfly requires established chinquapin canopy and exists only in a few locations in Washington, making it vulnerable to extirpation if fire occurs in its current habitat distribution during key adult and larval periods (June-September), kills its current host trees, or significantly reduces available forage (nectar plants).
Columbia Clubtail	Moderate-High	Low	Moderate-High	Moderate-High	> Increased air and water temperatures > Altered flow regimes (low summer flows and increased winter flooding)	Although very little information is available, Columbia Clubtail sensitivity is likely driven by water temperature, air temperature, and altered flow regimes (summer low flows and winter flooding). Eggs are laid in water, and after hatching, larvae burrow and overwinter in river mud. Water temperature influences emergence timing, while warmer air temperatures influence adult flight times, affecting foraging and energy demands. Reduced summer streamflow can exacerbate increasing water temperatures and effects on clubtail aquatic eggs and larvae. In addition, lower streamflows may strand eggs or larvae, causing mortality via desiccation. Increased winter flooding that enhances scour and/or that causes significant sedimentation may reduce larval survival.
Columbia Oregonian	Moderate-High	Low	Moderate-High	Moderate-High	> Increased temperatures > Reduced soil moisture and/or drought > Altered fire regimes	There is limited information on the sensitivity of the Columbia Oregonian to climate change. This species is found in low-elevation seeps and streams of the Columbia River Gorge as well as mid-elevation upland habitats (2565 to 3280 feet) in hemlock forests. In each of these locations, the species finds cover provided by herbaceous riparian vegetation in aquatic environments and large woody debris in forests. Loss of these refugia would likely alter the temperature and moisture regimes – low temperature and moderate to high humidity – upon which this species relies.
Columbia River Tiger Beetle	Moderate	Moderate	Moderate	Moderate	> Increased amount and/or duration of flooding	The Columbia River Tiger Beetle occupies stable river sandbars and riparian sand dunes. They are likely sensitive to flooding, soil moisture, and temperature. Soil moisture and temperature may affect larval development, as larvae grow and molt in sand/soil burrows that draw moisture from adjacent rivers/streams. Flooding or prolonged inundation can cause larval mortality by washing away larval burrows and/or causing suffocation via submersion, although they can survive up to 3 weeks of inundation. Sandbars occupied by this species are typically

INVERTEBRATES						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						large enough (extend more than 300 feet away from river) to avoid complete inundation during spring floods. Backwater flooding resulting from dam construction is thought to have extirpated all Washington populations.
Crowned Tightcoil	Low-Moderate	Low	Low	Moderate	> Increased temperatures > Reduced soil moisture and/or drought > Altered fire regimes	There is limited information on the sensitivity of the Crowned Tightcoil to climate change, and very limited information on this species' life history, although it is associated with riparian and old growth habitat. Its abundance is closely correlated with cool, moist conditions. Activities or events that alter conditions, such as moisture levels, shade, and temperature, may make this species vulnerable.
Dalles Hesperian	Moderate-High	Low	Moderate-High	Moderate	> Increased temperatures > Reduced soil moisture and/or drought > Altered fire regimes	There is limited information on the sensitivity of the Dalles Hesperian to climate change. This terrestrial species seeks refugia in locations with high humidity and relatively constant temperature (e.g., rock talus, under moist vegetation, deep in cracks in mud). Activities or events that alter conditions, such as moisture levels, shade, and temperature, may make this species vulnerable.
Dalles Juga	Moderate-High	Low	Moderate-High	Moderate	> Altered flow regimes > Reduced oxygen > Increased water temperatures	There is limited information on the sensitivity of the Dalles Juga to climate change and very limited information on this species' life history. The Dalles Juga is found at low-elevation springs and streams in cool, clean, highly oxygenated water. This species may therefore be sensitive to changes in flow regimes and water temperatures that negatively impact dissolved oxygen levels and chemical and biological processes
Dalles Sideband	Low-Moderate	Low	Low	Moderate	> Increased temperatures > Reduced soil moisture and/or drought > Altered fire	There is limited information on the sensitivity of this species to climate change. This species is frequently found in cool, moist talus habitat and upland forest areas that are near riparian corridors. Activities or events that alter conditions, such as moisture levels, shade, and temperature, may make this species vulnerable.

INVERTEBRATES						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
					regimes	
Dry Land Forestsnail	Low-Moderate	Low	Low	Moderate	> Increased temperatures > Reduced soil moisture and/or drought > Altered fire regimes	There is limited information on the sensitivity of this species to climate change. Its habitat includes talus and rocky riparian areas. Activities or events that alter conditions, such as moisture levels, shade, and temperature, may make this species vulnerable.
Giant Palouse Earthworm	Low-Moderate	Low	Low	Moderate-High	> Increased temperatures > Reduced soil moisture	There is little information on the sensitivity of the Giant Palouse Earthworm (GPE) to climate change, largely due to the fact that very little is known about this species in general. The GPE likely exhibits sensitivity to temperature; it can experience mortality from high soil temperatures, and utilizes deep burrows to survive hot, dry summer periods. Increasing temperatures and increasingly xeric conditions may reinforce this behavior. The GPE may also be sensitive to precipitation shifts and fire, as these regimes affect vegetative cover and can modify microhabitat and soil conditions, but links between precipitation, disturbance, vegetation, and GPE abundance are not clear at this time.
Great Arctic	Low-Moderate	Low	Low-Moderate	Low-Moderate	> Altered fire regimes	There is no information regarding the sensitivity of this species to climate change, and very little known regarding its life history. As an occupant of forest openings and meadow edges, it may benefit from more frequent fire which contributes to the creation of these habitat characteristics. However, larvae are thought to develop on grasses, and could be killed by fire. Small population sizes and limited distribution in Washington make it vulnerable to extirpation.
Hatch's Click Beetle	Moderate-High	Low	Moderate	Moderate-High	> Changes in precipitation (snow and rain) > Increased amount and/or duration of flooding	Hatch's Click Beetle occupies low elevation sphagnum bogs, and its climate sensitivity is likely driven by changes in habitat availability. Reduced water availability and quality (i.e., due to precipitation shifts, reduced snowpack, earlier snowmelt) can affect bog water levels and seasonal bog duration, potentially altering habitat extent. This species is likely sensitive to both bog drying and prolonged inundation from flooding. Adults feed primarily on flowering shrubs, although they may also prey upon invertebrates. Shifts in abundance and flower timing (i.e., phenology) of flowering shrubs in response to climate change may

INVERTEBRATES						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
					> Drought > Increased temperatures	affect Hatch's Click Beetle foraging and fitness, particularly since adult beetles are only active for short periods in the early spring. Warmer temperatures may increase beetle activity; Hatch's Click Beetles have historically been most active on hot days.
Hoary Elfin	Low-Moderate	Low	Low-Moderate	Low-Moderate	> Altered fire regimes	There is no information regarding the physiological sensitivity of this species to climate change, but it may be limited by temperature, as it currently appears only in lower elevation areas of Washington, even though its host plant exists at higher elevations. Hoary Elfin is likely sensitive to climate-driven changes in its larval host plant, kinnikinnick. Kinnikinnick is resilient to dry conditions. Fire maintains the open, high sunlight environments preferred by kinnikinnick and occupied by the Hoary Elfin (e.g., prairies, forest opening balds), but kinnikinnick may be sensitive to increasing fire frequencies and severities, as it appears to be adapted to low severity fire and to exhibit moderate survival and recovery post-fire.
Hoder's Mountainsnail	Low-Moderate	Low	Low	Moderate-High	> Increased temperatures > Reduced soil moisture and/or drought > Altered fire regimes	There is limited information on the sensitivity of this species to climate change. It is known to occur in grasslands and along timber edges including *Eriogonum* sp. and *Balsamorrhiza Sagitta*. Activities or events that alter conditions, such as moisture levels, shade, and temperature, may make this species vulnerable.
Hoko Vertigo	Low-Moderate	Low	Low	Moderate	> Increased disease outbreaks > Altered fire regimes	There is limited information on the sensitivity of the Hoko Vertigo to climate change. This species is only found at two sites on the Hoko River in the northwestern Olympic Mountains, although its range may extend into British Columbia. These two known locations are low elevation, old growth riparian areas. Because this species is so rare, it may be acutely vulnerable to fire, disease, or other events causing mass mortality as they may not be able to quickly rebuild populations.
Idaho Vertigo	Low-Moderate	Low	Low	Moderate	> Increased temperatures > Reduced soil moisture	There is limited information on the sensitivity of this species to climate change. It is found in a mid-elevation grass and sedge meadow with springs, seeps, bogs and fens. Activities or events that alter conditions, such as moisture levels and temperature, may make this species

INVERTEBRATES						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
					and/or drought > Altered fire regimes	vulnerable.
Island Marble	Moderate-High	Low	Moderate-High	Moderate	> Increased temperatures > Changes in precipitation > Sea level rise and storm surges > Altered fire regimes	Island Marble sensitivity is likely driven by temperature, precipitation, sea level rise, storm surges, and fire. Cool, wet spring conditions appear to limit Island Marble flight periods and fecundity, and recovery during warm, dry years is not guaranteed due to other habitat stressors. Shifts in temperature and precipitation may also affect larval foraging and survival by causing a mismatch between host plant phenology and larval emergence. Sea level rise paired with storm surges and windy conditions can inundate or cause significant sediment alteration in coastal habitats of Island Marble (e.g., among dunes and backing lagoons). Storm events and sea level rise can cause larval and pupal mortality and contribute to temporary or permanent habitat loss due to inundation, burial of host and forage plants, and loss of anchoring substrate and woody debris required for vegetation establishment. Island Marble is associated with a variety of grassland species (e.g., native and non-native mustards) that excel at colonizing disturbed sites, so population recovery post-storm is possible if host plants are able to re-establish. Due to its association with disturbance-adapted host plants, increasing fire frequencies may expand habitat for island marble and/or help maintain existing habitat by preventing grassland succession to shrub or forest types. However, large, high intensity fires occurring in current habitat areas could extirpate local island marble populations.
Johnson's Hairstreak	Moderate-High	Low	Moderate-High	Moderate	> Changes in precipitation > Altered fire regimes	Johnson's Hairstreak likely exhibits some physiological sensitivity to temperature and precipitation, with inclement weather delaying emergence and reducing diurnal activity. This butterfly may also be sensitive to moisture declines, as it has been documented drinking from puddles. This species is also likely sensitive to climate-driven changes in its larval host plant, dwarf mistletoe, which is a parasitic plant in conifer forests (e.g., western larch), particularly old growth. Increasing fire frequency, intensity, and severity may reduce dwarf mistletoe abundance in the short term, reducing habitat availability for Johnson's

INVERTEBRATES						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						Hairstreak.
Juniper Hairstreak	Moderate	Low	Moderate	Moderate	> Altered fire regimes	Temperature and precipitation likely affect larval forage periods. The sensitivity of Juniper Hairstreak is likely largely driven by climate-driven shifts in its larval host plant, western juniper. Western juniper is shade-intolerant, and fire helps prevent succession to conifer forest types in juniper stands. However, western juniper is also fire-intolerant, typically experiencing high fire mortality but still able to recolonize post-fire. Increasing fire frequency and severity may help maintain Juniper Hairstreak habitat by preventing succession, but can also lead to short-term habitat loss if fire burns in current habitat areas. Warmer and more xeric conditions may favor the expansion of western juniper woodland habitats, potentially benefitting Juniper Hairstreak.
Leschi's Millipede	N/A	N/A	N/A	N/A	N/A	This species was only classified in 2004 in Washington. There is almost no information available about its life history characteristics and no information available regarding it sensitivity to climate change.
Limestone Point Mountainsnail	Low-Moderate	Low	Low	Moderate	> Increased temperatures > Reduced soil moisture and/or drought > Altered fire regimes	There is limited information on the sensitivity of this species to climate change. It is closely associated with mid-elevations on limestone outcrops and talus. Activities or events that alter conditions, such as moisture levels and temperature, may make this species vulnerable.
Mad River Mountainsnail	Low-Moderate	Low	Low	Moderate-High	> Increased temperatures > Reduced soil moisture and/or drought > Altered fire regimes	There is limited information on the sensitivity of this species to climate change. It is found in talus under black cottonwood and bigleaf maple. Activities or events that alter conditions, such as moisture levels and temperature, may make this species vulnerable.
Makah Copper	Moderate-High	Low	Moderate-High	Moderate	> Changes in precipitation (snow and rain)	There is no information on the physiological sensitivity of this species to climate change. However, Makah Copper is likely sensitive to climate-driven changes in its larval host plant, bog cranberry, which occupies very wet and moist fens and bogs. Bog cranberry is not widely

INVERTEBRATES						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
					> Increased amount and/or duration of flooding > Drought	distributed, and drier conditions paired with increased winter flooding may affect the hydrology, formation and extent of bog habitat (see habitat sensitivity summary), potentially leading to habitat reductions for both bog cranberry and Makah Copper. Although bog habitats rarely burn, bog cranberry typically benefits from fire, increasing in abundance. It is unknown how Makah Copper responds to fire, however.
Mann's Mollusk-eating Ground Beetle	Moderate-High	Low	Moderate	Moderate-High	> Increased temperatures > Drought > Increased amount and/or duration of flooding	Very limited sensitivity information is available for this species. This species is thought to occupy riparian sections of lowland river canyons, and to seek out shaded, moist areas during the daytime. Its micro- and macrohabitat preferences likely make it sensitive to flooding, increasingly xeric conditions, and temperature increases.
Mardon Skipper	Moderate-High	Low	High	Moderate	> Increased temperatures > Changes in precipitation > Altered fire regimes	Climate sensitivity of this species is likely influenced by temperature, precipitation, and fire. Population numbers vary annually in response to variable weather because Mardon Skippers exhibit physiological and indirect (i.e., habitat) sensitivity to temperature and precipitation. Temperature influences butterfly behavior (e.g., foraging time), adult life span, and larval development. Warming temperature may also affect phenological timing between Mardon Skipper and key plant species (host and nectar plants) and cause desiccation of larval forage, leading to larval and/or adult starvation. In higher elevation sites, warming temperatures leading to reduced snowpack/earlier snowmelt may also expose Mardon Skipper larvae to novel environmental conditions, which could increase mortality. Precipitation also affects adult behavior, and extreme precipitation can cause adult mortality (i.e., by preventing foraging) and/or drown larvae. Moist conditions can also contribute to fungal development. Mardon Skippers are also vulnerable to fire. Fire helps maintain open grassland habitat used by the Mardon Skipper by preventing conifer encroachment, but Mardon Skippers are not very mobile, and fire can cause direct mortality of all life stages. Increasing fire frequencies may expand overall habitat area available for Mardon

INVERTEBRATES						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						Skipper, but could contribute to population extirpation if fire occurs in current habitat areas.
Masked Duskysnail	Low-Moderate	Low	Low-Moderate	Moderate	> Altered flow regimes leading to increased nutrient runoff > Reduced oxygen > Increased water temperatures > Increased disease outbreaks	There is limited information on the sensitivity of the Masked Duskysnail to climate change. This species displays very similar traits, habitat requirements, and global distributions to the Washington Duskysnail. The Masked Duskysnail's range is restricted to two large kettle lakes in eastern Washington – Curlew Lake in Ferry County and Fish Lake in Wenatchee National Forest. This species is considered to be a mud specialist, living on soft bottom substrates in highly oxygenated, cool lakes (preferring temperatures below 64°F); changes in water temperature and flow regimes that affect dissolved oxygen levels and stratification may therefore negatively affect the Masked Duskysnail. Changes in flow regimes that increase nutrient runoff may cause dense filamentous algae blooms that impair or prevent access to important food resources. This species occurs in low densities in isolated populations and therefore may be acutely vulnerable to diseases or other disturbance regimes causing mass mortality because they may not be able to quickly rebuild populations.
Meadow Fritillary	Low-Moderate	Low	Low-Moderate	Moderate	> Increased temperatures > Changes in precipitation > Altered fire regimes	There is almost no information regarding the sensitivity of this species to climate change, particularly in Washington. Similar to other butterflies, it is likely physiologically sensitive to changes in precipitation and temperature, which may affect larval development and adult behavior. Increasing fire frequency may help maintain and prevent succession of its meadow and forest opening habitat. Riparian habitat may be affected by increasing flood frequencies, as well as fire (see habitat summaries).
Mission Creek Oregonian	N/A	N/A	N/A	N/A	N/A	There is no information on the sensitivity of this species to climate change.
Monarch	Moderate	Moderate	Moderate	Moderate	> Increased temperatures > Changes in precipitation and/or drought	Monarch climate sensitivity is likely influenced by temperature, precipitation, and drought. Monarchs breed and migrate through Washington, and warmer temperatures may accelerate Monarch larval development and enhance adult reproductive activity, potentially expanding suitable breeding ranges northward where they may have historically been limited by cold temperatures. Warmer temperatures and shifts in winter precipitation at overwintering sites (e.g., California)

INVERTEBRATES						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						may also cause earlier flight times and arrival of migrants from southern overwintering grounds. Shifts in temperature and precipitation are also likely to influence milkweed abundance and distribution, which will impact Monarch distribution, migratory pathways and reproductive success. Drought reduces milkweed survival, germination, growth and seed production, and may make milkweed less palatable, affecting Monarch larval growth and survival.
Morrison's Bumble Bee	Moderate	Low	Moderate	Moderate	> Increased temperatures > Changes in precipitation and/or soil moisture	There is almost no information regarding the sensitivity of this species to climate change, particularly in Washington. It may be sensitive to climate-driven changes in dry scrub habitat (e.g., due to increasing fire, altered precipitation and soil moisture), particularly if disturbance events affect ground nests or foraging opportunities in spring and summer. In general, bumble bees are likely sensitive to climate-driven changes in nesting, foraging, and overwintering habitat, but detailed information is currently lacking. Shifts in temperature, precipitation, and snowpack may affect bumble bee distribution and life history, potentially forcing them into unfavorable habitats, to emerge at non-optimal times (i.e., mismatch with vegetation), and/or affecting energy demands during overwintering periods. These climate-driven changes may also affect habitat quality and availability. One of the primary concerns for bumble bee species is a shift in the abundance, distribution, and/or phenological synchrony of key forage flowering vegetation, as pollen and nectar availability influences reproduction and overwintering success of queens.
Nimapuna Tigersnail	N/A	N/A	N/A	N/A	N/A	There is no information on the sensitivity of this species to climate change.
Northern Forestfly	High	High	High	Moderate-High	> Increased water temperatures > Reduced glacier size and increased	The Northern Forestfly is a species of stonefly with only one currently known location in the northern Cascades. It is associated with a high-elevation spring and stream which flows into an alpine lake, and in fact all three species in the *Lednia* genus are restricted to alpine or subalpine springs and glacial streams (the proposed name for the genus is "Meltwater Stoneflies"). This species is extremely sensitive to climate change because of its dependence on coldwater habitats, which are

INVERTEBRATES						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
					glacier melting	likely to warm significantly along with disappearing glaciers.
Olympia Oyster	High	High	High	Moderate-High	> Declines in salinity > Decreased oxygen and pH	Olympia Oysters are likely to be sensitive to a number of climate factors, including declines in salinity, oxygen, and pH. Olympia Oysters are sensitive to low salinity levels, and potential increased precipitation (particularly during winter and spring) can lead to lower salinity levels and potential juvenile mortality, as juveniles have a more sensitive salinity threshold. Additionally, increases in extent and time of hypoxic conditions could limit oyster growth. Predicted declines in ocean pH in Washington are also likely to lead to decreases in growth, weight, and metamorphic success of oyster larvae, which could also trigger increased mortality at later life stages. The effects of acidification on oyster larvae could be more severe if low pH conditions are coupled with decreases in phytoplankton food availability.
Olympia Pebblesnail	Low-Moderate	Low	Low-Moderate	Moderate	> Altered flow regimes > Reduced oxygen > Increased water temperatures	There is limited information on the sensitivity of the Olympia Pebblesnail to climate change. This species displays very similar traits and habitat requirements to the Ashy Pebblesnail. The Olympia Pebblesnail's habitat range is believed to include Columbia River Basin's rivers, streams, and creeks, as well as some sites in the Olympic Mountains and San Juan Islands and the Willamette River system in Oregon. The Olympia Pebblesnail requires clear, cold, highly oxygenated streams, and therefore may be sensitive to changes in flow regimes and increases in water temperature that negatively impact dissolved oxygen levels and chemical and biological processes. Changes in flow regimes that increase nutrient runoff may cause dense algae blooms that impair or prevent the Olympia Pebblesnail's access to important food resources (e.g., lithophytes). The invasive New Zealand Mudsnail (*Potamopyrgus antipodarum*) may be a direct competitor for food and habitat.
One-band Juga	Moderate-High	Low	Moderate-High	Moderate	> Altered flow regimes > Reduced oxygen > Increased water	There is limited information on the sensitivity of this species to climate change. Its habitat includes low- to mid-elevation streams and springs with cold, highly oxygenated water, and therefore may be sensitive to changes in flow regimes and increases in water temperature that negatively impact dissolved oxygen levels and chemical and biological processes.

INVERTEBRATES						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
					temperatures	
Oregon Branded Skipper	Moderate	Low	Moderate	Moderate	> Increased temperatures > Changes in precipitation > Altered fire regimes	There is no information on the physiological sensitivity of this species to climate change, however, similar to other butterflies, larval development and adult activity are likely affected by temperature and precipitation. Climate sensitivity of Oregon Branded Skipper is also likely affected by fire. Increasing fire frequency may help maintain glacier outwash prairie habitat by preventing conifer or shrub encroachment, as well as create bare ground patches utilized by this skipper. However, more frequent fire may facilitate invasive species establishment, which could degrade Oregon Branded Skipper habitat (e.g., by occupying bare ground zones).
Oregon Megomphix	Low-Moderate	Low	Low	Moderate	> Altered fire regimes > Increased temperatures > Reduced soil moisture > Increased wind disturbance	There is limited information on the sensitivity of the Oregon Megomphix to climate change. This rare species is found at low elevations (below 490 feet) on well-shaded slopes near streams in Washington. Its distribution is closely associated with the bigleaf maple—the more bigleaf canopy cover, the more likely Oregon Megomphix is present. Activities or events that disturb canopy cover and litter composition, such as wind and fire, may therefore negatively affect the temperature and moisture levels at which this species is best suited.
Oregon Silverspot	Moderate	Low	Moderate	Moderate	> Increased temperatures > Drought	Oregon Silverspot exhibits some physiological sensitivity to temperature and precipitation, as larval development, pupation, and adult emergence timing vary each year according to weather, and adults exhibit thermoregulatory behavior during cold, windy conditions (e.g., shelter in warmer adjacent forest edges). Warmer temperatures may increase adult activity (i.e., less basking time) and/or accelerate larval development. Oregon Silverspot is also sensitive to climate-driven changes in habitat availability and quality. Increasing fire frequencies may help maintain the low stature coastal grassland this species requires and help prevent succession to forest or shrub ecotypes. Increasing fire frequency will likely also facilitate reproduction and germination of early blue violet, the larval host plant for Oregon Silverspot. Early blue violet is a shade-intolerant species that reproduces and germinates best in early successional coastal grasslands with bare soil or low, sparse grass cover. Early blue violet is also tolerant of hot,

INVERTEBRATES						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						dry periods, which will help maintain long-term Oregon Silverspot habitat areas under a warmer, drier climatic regime. However, dry years may cause early senescence of early blue violets, which can cause larval mortality.
Pacific Clubtail	Moderate-High	Low	Moderate-High	Moderate-High	> Increased air and water temperatures > Altered flow regimes (low summer flows and increased winter flooding) > Altered fire regimes	There is little information on the sensitivity of Pacific Clubtail to climate change. However, Pacific Clubtail sensitivity is likely influenced by air temperature, water temperature, and shifting flow regimes. Temperature is known to influence the phenology, development, behavior and other characteristics of dragonflies, and warming temperatures (both air and water) will likely impact this species during various life stages. Hydrological changes (e.g., reduced stream flows) and drought may degrade or reduce aquatic habitat available for this species and/or compound increases in water temperature. Pacific Clubtail is also likely sensitive to disturbance events (e.g., fire, floods) that reduce riparian vegetation, which eliminates stream shade and foraging and roosting sites for adults, and/or that increase siltation, which can kill larvae.
Pacific Needlefly	Moderate-High	Low	Moderate-High	Moderate	> Increased water temperatures > Changes in precipitation and/or drought > Altered flow regimes	The Pacific Needlefly is an uncommon species found only in mountainous regions of Oregon, Washington, and northern California. Little is known about this species, whose larvae are found only in seeps, springs, and small spring-fed streams. The genus *Megaleuctra* is dependent on coldwater habitats that do not dry out, as well as high water quality. The sensitivity of this species is likely closely tied to their specialized habitat requirements. Changes in flow patterns due to drought or changing patterns of precipitation, changes in water temperature, and decreased water quality are all likely to increase the sensitivity of the species. Habitat fragmentation and nearby development also alter the quality and availability of suitable habitat.
Pacific Vertigo	Low-Moderate	Low	Low	Moderate	> Increased disease outbreaks > Altered fire regimes	There is limited information on the sensitivity of the Pacific Vertigo to climate change. Typical Vertigo habitat includes moist riparian zones as well as dry forests; the Pacific Vertigo is closely associated with primarily deciduous and occasionally coniferous trees and bushes. This species is believed to be very rare in the region. Because this species is so rare, it may be acutely vulnerable to fire, disease, or other events causing mass mortality as they may not be able to quickly rebuild populations.

INVERTEBRATES						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
Pinto Abalone	Moderate-High	Moderate	Moderate-high	Moderate-High	> Decreased pH > Increased ocean temperatures	The main sensitivity of Pinto Abalone to climate change is likely to be from direct physiological responses to predicted decreases in pH. In laboratory experiments, elevated carbon dioxide levels led to decreased larval survival and increased shell abnormalities in Pinto Abalone. In other abalone species, simulated ocean acidification conditions have also resulted in decreased hatching rates and reduced larvae survival. Potential climate-related changes in preferred habitat of kelp beds with coralline algae could increase the sensitivity of this species, as these habitats may be sensitive to increasing sea surface temperature and could experience declines, thus limiting potential abalone habitat. Increases in sea surface temperature could also lead to decreased abalone reproduction and increased mortality. Given the current low population densities and recruitment levels of Pinto Abalone, any future threats from lower pH or increasing temperature could have an even greater impact on this species.
Poplar Oregonian	Low	Low	Low	N/A	N/A	There is limited information on the sensitivity of the Poplar Oregonian to climate change, and very limited information on this species' life history. Populations are found in moderately dry and cool, low elevation talus habitats in river basins. This species appears to be well adapted to drier habitats than other terrestrial snails, and therefore may be less susceptible to changes in moisture levels.
Propertius' Duskywing	Moderate	Low	Moderate	Moderate	> Increased temperatures	Propertius' Duskywing sensitivity is likely driven by temperature. This species exhibits some physiological sensitivity to warming temperatures, as well as indirect sensitivity to temperature via habitat changes. A study of Canadian populations found that adult flight phenology varied according to daily temperature, although larval development did not vary with temperature directly. A separate study found that warmer winter temperatures (+40°F higher than average) enhanced energetic drain on overwintering larvae and caused sublethal effects, and that increasing winter temperatures are likely to enhance desiccation stress for this species. Warming temperatures are also likely to affect the timing and distribution of key larval and adult food resources. As a specialist on certain oak species, phenology mismatches with host plants could affect adult and larval survival, but an extended growing season could enhance larval growth prior to overwintering. Further, a

INVERTEBRATES						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						lag between Propertius' Duskywing and oak polar migration in response to warming temperatures is predicted, which will likely limit this species' dispersal potential in response to climate change.
Puget (Blackmore's) Blue	Alpine populations - High Low elevation populations - Low-Moderate	Moderate	Alpine populations - High Low elevation populations - Moderate	Olympics: Moderate-High South Puget Sound: Low-Moderate	> Increased temperatures > Reduced snowpack > Altered fire regimes	Sensitivity of this species is mainly driven by habitat. Populations associated with alpine meadows in the Olympic Mountains are likely very sensitive to climate-driven changes in habitat availability, as alpine habitats are projected to decline in extent due to warming temperatures, reduced snowpack, drought, and other drivers. Populations associated with lower elevation prairies are likely sensitive to fire. Lupine, the larval host plant of the Puget Blue as well as an adult nectar source, appears to thrive post-fire, and fire also helps prevent prairie succession to forest or shrub habitats. However, fire can also lead to direct mortality of Puget Blue adults and larvae, and/or facilitate the expansion of Scot's broom and other invasive plants, which can displace lupine. In addition, it is unknown how shifting fire regimes (e.g., seasonality, intensity) will impact this species and its host plant.
Puget Oregonian	Low-Moderate	Low	Low	Moderate	> Increased temperatures > Reduced soil moisture and/or drought > Altered fire regimes	There is limited information on the Puget Oregonian to climate change. This species is found in cool, moist conifer forests at low to moderate elevations, especially under large woody debris and leaf litter. This shade provides refugia from moderate fluctuations in temperature and moisture; changes in canopy cover may therefore negatively impact this species.
Puget Sound Fritillary	Low-Moderate	Low	Low-Moderate	Moderate	> Altered fire regimes	There is limited information on the sensitivity of the Puget Sound Fritillary to climate change. Similar to other butterflies that occupy prairie and forest glade habitats, the Puget Sound Fritillary is likely sensitive to fire, which can help prevent grassland succession to shrub or forest habitat, but can likely cause direct butterfly mortality and/or facilitate invasion and spread of invasive species.
Rainier Roachfly	Moderate-High	High	Moderate-High	Moderate-High	> Increased water temperatures > Reduced glacier size	The Rainier Roachfly has only been documented within Mt. Rainier National Park (mostly on the west side). It is found in seeps, springs, and small spring-fed streams. Climate sensitivity for this species is tied to melting glaciers and an associated rise in stream temperatures. Relatively little is known about this species, but stoneflies as a whole are

INVERTEBRATES						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
					and increased glacier melting > Changes in precipitation and/or drought > Altered flow regimes	sensitive to drought or precipitation changes that may affect seep moisture, springs, and stream flow. Decreased water quality, habitat fragmentation and nearby development also alter the quality and availability of suitable habitat.
Ranne's Mountainsnail	Low	Low	Low	N/A	N/A	There is limited information on the sensitivity of this species to climate change. It is known to occur on only one site in Chelan County in grassland including *Eriogonum* sp. and *Balsamorrhiza Sagitta*.
Salmon River Pebblesnail	N/A	N/A	N/A	N/A	N/A	There is no information on the sensitivity of this species to climate change.
Sand Verbena Moth	Moderate-High	Moderate	Moderate-High	Moderate	> Increased invasive species > Sea level rise > Increased coastal erosion > Drought	The Sand Verbena Moth is primarily threatened by the loss of its host plant and open sandy coastal habitat as a result of encroaching vegetation, including invasive species. However, it may also exhibit sensitivity to a variety of climate and climate-driven changes, including enhanced coastal erosion, sea level rise and drought. Disturbance is the primary driver in maintaining open sandy habitat preferred by the Sand Verbena Moth's host plant, yellow sand verbena. Enhanced coastal erosion could create more open sandy habitat (i.e., through increased deposition of eroded cliff material) or decrease current moth habitat through loss of established host plants, which occur close to the shoreline. Substantial sea level rise could inundate Sand Verbena Moth habitat, but projected rates of rise through mid-century will likely not be enough to inundate current habitat areas. Drought could lead to early senescence of yellow sand verbena, which would decrease food availability for both adults and larvae and affect annual population numbers. Yellow sand verbena is adapted to dry conditions, however, and can likely survive drought periods, so overall habitat area is not likely to decrease in response to drought.
Sasquatch Snowfly	Moderate	Low	Moderate	Moderate	> Increased water	The Sasquatch Snowfly has been found in British Columbia and Washington, and is associated with high elevation creeks and small to

INVERTEBRATES						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
					temperatures > Changes in precipitation and/or drought > Altered flow regimes	medium rivers. Little else is known about this species, which was recently separated from the nearly identical *Bolshecapnia Missiona*. Sensitivity for this species likely tied to habitat requirements. Like all other stoneflies, changes in flow patterns due to drought or changing patterns of precipitation, changes in water temperature, and decreased water quality are all likely to increase the sensitivity of the species. Habitat fragmentation and nearby development also alter the quality and availability of suitable habitat.
Shortface Lanx	Moderate	Low	Low-Moderate	Moderate-High	> Altered flow regimes > Reduced oxygen > Increased water temperatures > Increased disease outbreaks	There is limited information on the sensitivity of this species to climate change. This species is found in cold, perennial, highly oxygenated rivers and streams, and may therefore be sensitive to changes in flow regimes and water temperatures that negatively impact dissolved oxygen levels and chemical and biological processes. This species occurs in low densities in isolated populations and therefore may be acutely vulnerable to diseases or other regimes causing mass mortality because they may not be able to quickly rebuild populations.
Silver-bordered Fritillary	Moderate-High	Moderate	Moderate-High	Moderate-High	> Increased temperatures > Reduced snowpack > Altered flow regimes > Altered fire regimes	Climate sensitivity of Silver-bordered Fritillary is likely driven by habitat changes resulting from drying, altered hydrology, and fire. Warmer temperatures and precipitation shifts that drive reduced snowpack and altered flow regimes can lead to drying of bog, marsh and riparian habitats used by this species. Forest succession can also degrade habitat by reducing abundance of violet, its larval host plant. Increasing fire frequency and increasing winter flood risk may help maintain early successional habitat and the high violet abundance required by the Silver-bordered Fritillary. However, fire may cause adult and/or larval mortality.
Siuslaw Sand Tiger Beetle	Moderate-High	Low	Moderate	Moderate-High	> Reduced stream flow > Drought and/or reduced soil moisture	Siuslaw Sand Tiger Beetle occupies sandy beaches at the interface of river mouths and the Pacific Ocean. This species is likely sensitive to drought, reduced streamflow, and increasingly xeric conditions, as larvae have narrow moisture requirements and burrows are located adjacent to surface water or in areas with persistent soil moisture.
Sonora	Low-	Low	Low-	Low-	> Altered fire	There is limited information on the sensitivity of the Sonora Skipper to

INVERTEBRATES						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
Skipper	Moderate		Moderate	Moderate	regimes	climate change. As an occupant of forest edges, prairies, meadows and other open sites, this species may exhibit sensitivity to fire, which can help maintain open habitat conditions. However, similar to other prairie butterflies, fire may cause adult and/or larval mortality. It likely exhibits some physiological sensitivity to climate conditions, as population numbers fluctuate yearly, but more information is needed.
Spotted Taildropper	Low-Moderate	Low	Low-Moderate	Moderate	> Increased temperatures > Reduced soil moisture and/or changes in precipitation > Altered fire regimes	There is very limited information regarding the sensitivity of Spotted Taildropper to climate change and limited information available regarding its life history characteristics. Their main sensitivity is likely to be driven by changes in their preferred habitat – mature conifer forests with moist ground. Increases in temperature and decreases in summer rainfall are likely to lead to increased risk of severe fires, which would destroy habitat for this species. Declines in habitat quality could also lead to fragmentation of populations and eventual population declines, particularly because documented populations of this species are already very small.
Straits Acmon Blue	Moderate-High	Moderate	N/A	Moderate-High	> Sea level rise > Increased storm frequency and intensity	There is no information on the sensitivity of the Straits Acmon Blue to climate change. As an occupant of sand spits and beaches, it may be vulnerable to climate-driven shifts in habitat and host plant availability caused by sea level rise, increased storm frequency and intensity, and erosion, but no information is available. (See scrub and herb coastal vegetation habitat assessments for more information on potential habitat sensitivity to climate change.)
Subarctic Bluet	Moderate-High	Low	High	Moderate	> Altered flow regimes > Drought > Increased air and water temperatures > Reduced snowpack and/or changes in precipitation	The Subarctic Bluet is likely sensitive to drought, increasingly dry conditions (e.g., reduced snowpack, shifts from snow to rain), and altered hydrology (e.g., reduced flows and larger floods) that can lead to drying, habitat contraction and/or altered water quality in its fen and bog habitat. Subarctic Bluet larvae are aquatic and depend on aquatic vegetation for foraging, making them sensitive to climate-driven habitat drying that may facilitate shifts toward more xeric vegetation. There are only a few populations of this species in Washington, representing the southern end of this species' range, so any significant alteration in bog habitat as a result of climate change could lead to loss of this species in the state. Similar to other Odonates, Subarctic Bluet is likely also sensitive to increasing temperatures (air and water) in a variety of ways:

INVERTEBRATES						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						warmer temperatures may affect development, phenology, behavior, and other characteristics of this species.
Suckley Cuckoo Bumble Bee	Moderate	Low	Moderate	Moderate	> Increased temperatures > Changes in precipitation and/or soil moisture	There is no information regarding the sensitivity of this species to climate change. In general, bumble bees are likely sensitive to climate-driven changes in nesting, foraging, and overwintering habitat, but detailed information is currently lacking. Shifts in temperature, precipitation, and snowpack may affect bumble bee distribution and life history, potentially forcing them into unfavorable habitats, to emerge at non-optimal times (i.e., mismatch with vegetation), and/or affecting energy demands during overwintering periods. These climate-driven changes may also affect habitat quality and availability. One of the primary concerns for bumble bee species is a shift in the abundance, distribution, and/or phenological synchrony of key forage flowering vegetation, as pollen and nectar availability influences reproduction and overwintering success of queens.
Talol Springfly	Moderate	Low	Moderate	Moderate	> Increased water temperatures > Changes in precipitation and/or drought > Altered flow regimes	The Talol Snowfly was described in 2004 from a single collection taken from Mt. Rainier National Park. The sample was found in a medium-sized river, but nothing else is known about the ecology of this species. Like all other stoneflies, it is likely dependent on flowing water for nymph survival, making it sensitive to changes in flow patterns due to drought or changing patterns of precipitation. Stoneflies are also typically sensitive to changes in water temperature and water quality, as well as habitat fragmentation and nearby development which may alter the quality and availability of suitable habitat.
Taylor's Checkerspot	Moderate-High	Moderate	Moderate-High	Moderate-High	> Increased temperatures > Drought > Extreme precipitation events > Altered fire regimes > Increased invasive weeds	Taylor's Checkerspot sensitivity is likely driven by temperature, precipitation, and fire. Warming temperatures may accelerate larval development, affect larval feeding period duration, increase activity periods by reducing basking requirements, and increase total habitat use at the microsite level. However, increasingly xeric conditions may reduce the palatability of grassland larval host plants and/or cause earlier host plant senescence, contributing to larval starvation and mortality. Increasing drought frequency and severity may also require Taylor's Checkerspot to obtain moisture from puddles during spring, creating previously unneeded microhabitat requirements. Taylor's Checkerspot is also sensitive to rain, and extreme downpours could

INVERTEBRATES						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						cause severe population declines by washing away eggs and larvae and limiting adult flight. Low severity fire helps maintain the native vegetation used by Taylor's Checkerspot, but fire can also kill all butterfly age stages, potentially extirpate local populations if fires are large enough. Thus, increasing fire frequencies and severities may affect butterfly survival and habitat availability for Taylor's Checkerspot.
Three-band Juga	Moderate-High	Low	Moderate-High	Moderate	> Increased water temperatures > Reduced soil moisture and/or drought > Altered fire regimes	There is limited information on the sensitivity of this species to climate change. This species is found in shallow, slow-flowing springs and seeps and is sometimes associated with talus. Activities or events that alter conditions, such as moisture levels and temperature, may make this species vulnerable.
Unnamed Oregonian (*Cryptomastix mullani hemphilli*)	N/A	N/A	N/A	N/A	N/A	There is no information on the sensitivity of this species to climate change.
Valley Silverspot	Low-Moderate	Low	Low-Moderate	Low-Moderate	> Altered fire regimes	There is limited information on Valley Silverspot sensitivity to climate change, but it is likely sensitive to fire. Valley Silverspot prefers open grassland habitat, and its host plant, early blue violet, thrives in early successional landscapes; fire likely helps maintain open grassland habitat by preventing forest succession. However, increasing fire frequency may facilitate the expansion of Scot's broom and other invasive plants, which can outcompete violets, reducing host plant availability.
Washington Duskysnail	Low-Moderate	Low	Low-Moderate	Moderate	> Altered flow regimes > Reduced oxygen > Increased water temperatures	There is limited information on the sensitivity of the Washington Duskysnail to climate change. This species displays very similar traits, habitat requirements, and global distributions to the Masked Duskysnail. The Washington Duskysnail occurs in Washington and Montana; in Washington, their habitat includes two large kettle lakes in eastern Washington – Curlew Lake in Ferry County and Fish Lake in Wenatchee National Forest. This species is considered to be a mud

INVERTEBRATES						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
					> Increased disease outbreaks	specialist, living on soft bottom substrates in highly oxygenated lakes; changes in water temperature and flow regimes that affect dissolved oxygen levels and stratification may therefore negatively affect the Washington Duskysnail. Changes in flow regimes that increase nutrient runoff may cause dense filamentous algae blooms that impair or prevent access to important food resources. This species occurs in low densities in isolated populations and therefore may be acutely vulnerable to diseases or other regimes causing mass mortality because they may not be able to quickly rebuild populations.
Wenatchee Forestfly	Moderate-High	Low	Moderate	Moderate-High	> Increased water temperatures > Changes in precipitation and/or drought > Altered flow regimes	The Wenatchee Forestfly is a type of stonefly which has been found only in springs which flow into Lake Wenatchee, Washington. Little else is known about this species, but sensitivity probably is tied to specialized habitat requirements. Like all other stoneflies, changes in flow patterns due to drought or changing patterns of precipitation, changes in water temperature, and decreased water quality are all likely to increase the sensitivity of the species. Habitat fragmentation and nearby development also alter the quality and availability of suitable habitat.
Western Bumble Bee	Moderate-High	Low	Moderate-High	Moderate-High	> Increased temperatures > Reduced snowpack > Earlier snowmelt > Altered fire regimes	Climate sensitivity of the Western Bumble Bee is likely driven by temperature increases, reduced snowpack and earlier snowmelt, and fire. In Washington, this species occupies primarily higher elevations; temperature increases, reduced snowpack, and earlier snowmelt may be contributing to phenological mismatches between this species and key forage plants. Temperatures may also affect the distribution of this species, as it appears to prefer cooler environments. Increasing fire frequencies may help maintain bumble bee foraging habitat by preventing conifer encroachment on meadows with abundant flowers. In general, bumble bees are likely sensitive to climate-driven changes in nesting, foraging, and overwintering habitat, but detailed information is currently lacking. Shifts in temperature, precipitation, and snowpack may affect bumble bee distribution and life history, potentially forcing them into unfavorable habitats, to emerge at non-optimal times (i.e., mismatch with vegetation), and/or affecting energy demands during overwintering periods. These climate-driven changes may also affect

INVERTEBRATES						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						habitat quality and availability. One of the primary concerns for bumble bee species is a shift in the abundance, distribution, and/or phenological synchrony of key forage flowering vegetation, as pollen and nectar availability influences reproduction and overwintering success of queens.
Western Pearlshell	Moderate	Low	Moderate	Moderate	> Increased water temperatures > Altered flow regimes	Western Pearlshell is a very long-lived species with a lifespan of up to 100 years and it has experienced significant declines over the past few decades. This species is generally found in shallow pools of freshwater streams and reservoirs with good water quality and a sufficient abundance of small fish who serve as hosts for Western Pearlshell during its transition from the larval to juvenile stage. Therefore, main sensitivity is likely to stem from climate-induced changes in water quality and host fish abundance. For instance, increased intensity of winter storms could lead to higher flow in rivers and increased nutrient runoff, both of which would degrade and reduce available habitat. For this species, high levels of river discharge have been found to result in decreased recruitment, and higher nutrient levels have been associated with decreased juvenile growth and increased mortality. Additionally, increases in water temperature and nutrient runoff could lead to altered abundance of host fish (e.g., juvenile salmon) for the larval stage, thus leading to declines in abundance. The long generation times of this species is likely to make response and recovery to adverse climate conditions more difficult.
Western Ridged Mussel	Moderate	Low	Low-Moderate	Moderate-High	> Increased water temperatures > Altered flow regimes	There is limited information regarding the sensitivity of the Western Ridged Mussel to climate change. This species is generally found in shallow pools of freshwater creeks and streams and with good water quality and a sufficient abundance of small fish (e.g., sculpin and perch) who serve as hosts for Western Ridged Mussel during their transition from the larval to juvenile stage. Therefore, their main sensitivity is likely to stem from climate-induced changes in water quality and host fish abundance. For instance, increased intensity of winter storms could lead to higher flow in rivers and increased nutrient runoff, both of which would degrade and reduce available habitat. Additionally, increases in water temperature could lead to altered abundance of host fish for the larval stage, thus triggering declines in abundance, particularly since this

INVERTEBRATES						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						species appears to be a specialist in terms of preferred host fish species. Western Ridged Mussels may also be sensitive to increasing water temperature in streams and creeks; increased temperatures could lead to decreased recruitment and increased mortality of the larval stage.
White-belted Ringtail	Moderate-High	Low	Moderate-High	Moderate	> Increased air and water temperatures > Altered flow regimes (low summer flows and increased winter flooding) > Altered fire regimes	There is little information on the sensitivity of this species to climate change, but similar to the Pacific Clubtail, it is likely influenced by air temperature, water temperature, and shifting flow regimes. Temperature is known to influence the phenology, development, behavior and other characteristics of dragonflies, and warming temperatures (both air and water) will likely impact this species during various life stages. Hydrological changes (e.g., reduced stream flows) and drought may degrade or reduce aquatic habitat available for this species and/or compound increases in water temperature. White-belted Ringtail is also likely sensitive to disturbance events (e.g., fire, floods) that reduce riparian vegetation, which eliminates stream shade and foraging and roosting sites for adults, and/or that increase siltation, which can kill larvae.
Winged Floater	Moderate	Low	Low-Moderate	Moderate-High	> Increased water temperatures > Altered flow regimes	There is limited information regarding the sensitivity of Winged Floater to climate change. This species is generally found in lakes, reservoirs, and slow-moving streams with good water quality and a sufficient abundance of small fish (e.g., sculpin, perch, hardhead) who serve as hosts for the species during its transition from the larval to juvenile stage. Therefore, their main sensitivity is likely to stem from climate-induced changes in water quality and host fish abundance. For instance, increased intensity of winter storms could lead to higher flow in rivers and increased nutrient runoff, both of which would degrade and reduce available habitat. Additionally, increases in water temperature could lead to altered abundance of host fish for larval stage, thus leading to declines in abundance. Winged Floater may also be sensitive to increasing water temperature in streams and lakes; increased temperatures could lead to decreased recruitment and increased mortality of the larval stage.
Yosemite Springfly	High	Low	High	Moderate-High	> Increased water temperatures	The Yosemite Springfly is rare, found only in high elevation glacier-fed streams within Washington, Oregon, and California. Little else is known about this species, but sensitivity probably is tied to specialized habitat

INVERTEBRATES						
Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
					> Reduced glacier size and increased glacier melting > Changes in precipitation and/or drought > Altered flow regimes	requirements, which will be affected by melting glaciers and an associated rise in stream temperatures. Like all other stoneflies, changes in flow patterns due to drought or changing patterns of precipitation and decreased water quality are also likely to increase the sensitivity of the species, as well as habitat fragmentation and nearby development which may alter the quality and availability of suitable habitat.
Yuma Skipper	Moderate	Moderate	Moderate	Moderate	> Altered flow regimes > Prolonged drought	Yuma Skipper occupies reed beds around freshwater marshes, wetlands, streams, and other wet areas, and is likely sensitive to increasingly dry conditions that may affect the distribution and persistence of its larval host plant, the common reed. However common reed is fairly resilient, as it is able to persist for several years in dried-out wetlands; therefore, habitat for Yuma Skipper may be resilient to short-term drought, but could be vulnerable to long-term drought and/or significant shifts in surface water delivery to wetland areas. Further, the extremely limited distribution of Yuma Skipper in Washington makes it vulnerable to local extirpation.

C.3 References

SPECIES VULNERABILITY

References for species vulnerability can be found in Appendix F, under Climate Change Vulnerability.

CLIMATE IMPACTS OVERVIEW

The information in the climate impacts overview was compiled from various synthesis reports on climate change projections and impacts for the Pacific Northwest region. Specific citations for information not derived from these reports can be found in-text. Otherwise, primary literature sources can be found within the following synthesis reports:

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Tillman, P. and D. Siemann. 2011. Climate Change Effects and Adaptation Approaches in Freshwater Aquatic and Riparian Ecosystems in the North Pacific Landscape Conservation Cooperative Region: A Compilation of Scientific Literature. National Wildlife Federation. Available at: http://www.nwf.org/~/media/PDFs/Global-Warming/2014/Freshwater-Report/NPLCC_Freshwater_Climate-Effects_Final.pdf

Tillman, P. and D. Siemann. 2011. Climate Change Effects and Adaptation Approaches in Marine and Coastal Ecosystems of the North Pacific Landscape Conservation Cooperative Region: A Compilation of Scientific Literature. National Wildlife Federation. Available at: http://www.nwf.org/~/media/PDFs/Global-Warming/2014/Marine-Report/NPLCC_Marine_Climate-Effects_Final.pdf

Washington Wildlife Habitat Connectivity Working Group (WHCWG). 2010. Washington Connected Landscapes Project: Statewide Analysis. Washington Departments of Fish and Wildlife, and Transportation

Appendix D

Stakeholder Engagement and Outreach

Table of Contents

Appendix D
Stakeholder Engagement and Outreach

D.0 Introduction and Overview

The development process of the original Comprehensive Wildlife Conservation Strategy (CWCS) included significant outreach to the public and WDFW's stakeholders, all of which is detailed in the 2005 plan, available on the SWAP website – http://wdfw.wa.gov/conservation/cwcs/. The following chapter summarizes our approach to engage stakeholders in the review and revision of the CWCS and the development of the State Wildlife Action Plan (SWAP) Revision. In general, we aimed for a strategic and leveraged approach to engaging external partners. One of the guiding principles adopted early in the SWAP Revision process encouraged us to "be efficient – conduct the SWAP revision in a manner that matches the available resources for planning and implementation." With limited resources available for this revision, we focused on how to get the best value from stakeholder and public outreach efforts. An Outreach Plan, located near the end of this appendix, was developed to guide our efforts, and specific components of that plan are discussed in the next section.

Our overall approach was to provide several opportunities for feedback from our stakeholders and conservation partners throughout the SWAP Revision process, recognizing that input early in the process would be more effective at shaping the scope and content. We worked with the Wildlife Diversity Advisory Council (WDAC), a standing committee convened by WDFW and representing a range of interests as our primary stakeholder committee. During this period, the WDAC consisted of 18 members from across the state. We provided periodic updates to WDAC on the process for the SWAP Update and worked with a subcommittee early in the process for feedback on our content and focus areas, including feedback on the SGCN list and approach to identifying habitats of concern. Each member of the WDAC was encouraged to reach out to the people and organizations they interact with outside of WDFW to provide input during the revision.

Using the tools described below, we cast a wide net beyond the WDAC to identify and invite other individuals and organizations who might be interested in being involved in the development process, and then focused in on working with those who indicated interest. We made use of the WDFW website, email announcements, in person workshops, webinars and presentations, and briefings to small groups to announce the SWAP Update project and invite comments during the development process.

D.1 Development and Implementation of an Outreach Plan

We worked with members of the WDFW Cross Program Advisory Team[1] to develop an Outreach Plan which addressed both outreach to interested parties external to WDFW and also in-reach, activities to engage the expertise of staff within the agency. The Outreach Plan was then reviewed by members of the Wildlife Diversity Advisory Council, and after discussion, the plan was adopted (see References Section for the goals and objectives of the plan).

[1] The Cross Program Advisory Team included managers from across the agency and met monthly beginning in July 2013 to provide guidance and input on the development of the State Wildlife Action Plan Update.

A few of the key activities outlined in the plan are discussed below.

D.1.1 Use of the WDFW website for outreach

In early 2014, we updated the WDFW website to announce that the 2005 CWCS was being reviewed and revised as a State Wildlife Action Plan Update. We provided basic information about the update process and timeline and encouraged interested parties to contact the SWAP Coordinator for more information and to be on a list for future updates.

March 2015: SGCN list and supporting information

In early March we published our draft SGCN list on the website and provided information about the list, the criteria used, differences from 2005 and the implications of being included on the SGCN list. We also published fact sheets for each of the SGCN, including information on conservation status, conservation concern, distribution, population trends, habitat needs, key stressors and actions. Any visitor to the website was encouraged to review and submit comments on these documents, or the list itself.

July 2015: Full draft (content review only)

The full draft SWAP was posted on the website in late July for a general public review period. This draft was intended for content review only.

D.1.2 Developing an interested persons list

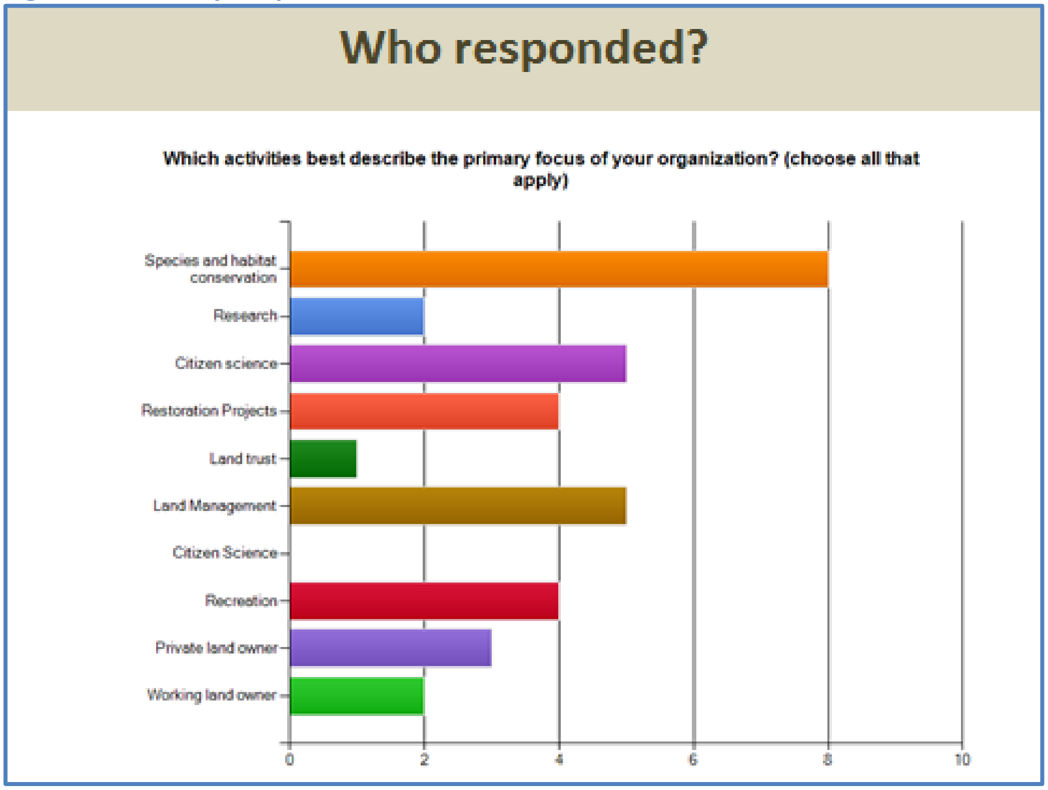
Early in the process we reviewed existing lists from within WDFW to identify individuals, tribes and organizations potentially interested in conservation issues or having specialized expertise or knowledge to contribute. An introductory email was sent to approximately 250 individuals and organizations, announcing the SWAP Update and our goal of developing a list of people interested in being involved in or kept informed of the process for updating the plan. We provided a brief overview of the purpose and intent of the SWAP Revision.

D.1.3 Survey to determine how the SWAP could add value to conservation actions of other organizations

We developed a survey, located near the end of this appendix, to find out generally how the State Wildlife Action Plan could add value to other organizations, and identify specific opportunities to contribute to shared conservation goals or strategies. The survey asked respondents to identify the top priority initiatives or objectives related to habitat or species conservation in a three to five year timeline, so that WDFW could assess how the agency, and specifically the SWAP, could contribute towards those objectives. We also provided a list of options for respondents to indicate how WDFW could assist in furthering shared goals related to species and habitat conservation. Finally, we included an open ended question specifically asking for ideas on how the SWAP itself could add value to their respective conservation efforts.

While the number of those who responded was relatively low (approximately 20), respondents represented a diverse group of interests and organizations, and the results were informative from that perspective. The following figures summarize the diversity of those who responded.

Figure D-1: Survey Respondents



Sample responses to "How the SWAP could add value to your work"

- Promote on the ground actions to conserve habitat, and access to habitat, especially given threat of climate change.
- Incentive for private landowners; facilitate private incentives for species recovery.
- Serve as a road map for private landowners to help them coordinate incentive based habitat plans with appropriate agencies and tribes.
- Be responsive to needs of agricultural community.
- Provide grant opportunities for land protection and public education projects.
- Promote citizen science at every age level (databases and field experts).
- Communicate to the public about species conservation and climate change
- Integrated/collaborative planning.
- Provide predictability about natural resources management issues; identify management actions that could become Army conservation projects.
- Incorporate priorities set by Pacific Coast Joint Venture Scientists.
- Help to set priorities for partners, and inform updates of national bird plans.

While the resources available for the SWAP Update and the focus of our revision did not allow us to address all the comments, the exercise provided good feedback to the agency and emphasized the importance of using a full conservation toolbox when considering appropriate actions to improve status of SGCN or Ecological Systems of Concern (ESOC), including technical assistance, transparent and clear communication, incentives for private landowners, increased education and others. These conservation tools can be as important in some cases as research or survey and monitoring activities.

The feedback from the survey as well as other comments received through the website and at SWAP presentations encouraged us to post information on SGCN early in our review to ensure that to the extent possible, experts had ample opportunity to add any appropriate information. In identifying stressors and actions (in SGCN and ESOC fact sheets), we also identified potential partners and included a full range of conservation tools.

D.1.4 Presentations and briefings to key conservation partners

Throughout the SWAP Revision process, the SWAP Coordinator provided briefings and updates to both small and large groups. The purpose was generally to outline the update process, share products as they were available, and gather feedback. We held briefings with each of the following organizations:

- WDNR Natural Heritage Program staff
- Pacific Coast Joint Ventures quarterly meeting
- USFWS staff from Region 1
- Audubon Washington & Black Hills Audubon
- USFWS Surrogate species program lead - identifying possible synergies
- USFS Region 6 TRACs program (purpose to identify possible synergies)
- Cascadia Partner Forum
- North Pacific Landscape Conservation Cooperative Steering Committee and staff
- Northwest Climate Science Center staff

D.1.5 In-person workshops and webinars

We scheduled three in-person workshops around the state and one webinar, and advertised these on our website and by email to interested persons. We timed the workshops to coincide with the release of the draft SGCN list on our website, and the availability of fact sheets for most of the species. The one to two-page fact sheets describe habitat, conservation status and need, stressors and actions (see Appendix A for updated versions of these fact sheets). The focus of the workshops was to provide an overview of all the elements of the update, but to focus particularly on the availability of the SGCN data on the web and encourage review of these draft products.

D.1.6 Targeted Outreach

After the draft SWAP was released for public review, we targeted outreach to key stakeholders that we wanted to be sure had an opportunity to provide comment. We offered webinars and in-person briefings to introduce the SWAP and tools that might be of interest. We reached out specifically to working landowner associations and tribes during August of 2015 to ensure they were aware of the public review draft of the SWAP and specific content that might be of interest to them. We were in phone contact with tribal representatives and sent announcements to tribal biologists through the Bureau of Indian Affairs as well as our own direct email lists.

Comments and responses to the Public Review Draft

We received 21 comments via email from external reviewers. Most of these comments were advocating that additional species be included as SGCN. A handful of other comments addressed specific issues in the SWAP or recommended clarifications. WDFW prepared edits in the SWAP itself in response to many of the comments and will prepare a full summary of comments and responses to post on the SWAP website.

D.2 References Section

D.2.1 Wildlife Diversity Advisory Council

Wildlife Diversity is a term commonly used to describe wildlife species that are not traditionally managed for harvest. Also known as "nongame", these species make up the majority of wildlife. The Wildlife Diversity Advisory Council (WDAC) was created to advise the Department on both keeping common species common and recovering listed wildlife species. The council also recommends approaches on how to develop and maintain the social, political, and resource support necessary to achieve conservation of wildlife diversity species in Washington.

Mission Statement

The purpose of the Wildlife Diversity Advisory Council (WDAC) is to advise the Department of Fish and Wildlife on matters pertaining to Wildlife Diversity (nongame species and habitat). At the Department's request, WDAC may focus on present or emerging issues as they relate to wildlife diversity.

D.2.2 Goals and Objectives of the SWAP Outreach Plan (adopted in August, 2014)

Goal

The purpose of this plan is to outline a set of meaningful and cost-effective outreach activities regarding WDFW's efforts to revise the SWAP. Our goal is to design and conduct these activities in such a way as to provide sufficient opportunities for interested parties to contribute to the content of the plan and/or provide substantive comments on specific elements before submission to the USFWS in September, 2015.

SPECIFIC OBJECTIVES (benchmarks)

1. Identify appropriate audience
    - Develop address and contact lists.
2. Develop outreach materials as necessary, to include a web page, fact sheet, PowerPoint presentations, email alerts to interested parties and materials to support interactive workshops.
3. Conduct outreach activities necessary to accomplish goal, to include at least two in person workshops and one webinar during development of the plan, and at least two webinars to introduce the final draft plan.
    - In person one-on-one meetings and calls, and presentations at appropriate events and workshops will be conducted as resources allow.
4. Ensure that the SWAP Revision timeline allows ample time for interested parties to participate in the process.
    - Schedule outreach activities to gather meaningful feedback and input.
    - Provide appropriate time for public review and comment on draft SWAP.

TARGET DELIVERABLES

1. Outreach materials: webpage, one-pager
2. Targeted audience presentations: 2-4
3. Public workshops/webinars : 3-5

D.2.3 Survey Monkey

Used to collect feedback on how the SWAP could add value to conservation work by WDFW conservation partners and others

STATE WILDLIFE ACTION PLAN

The purpose of this survey is to assess how the State Wildlife Action Plan could most effectively contribute to regional conservation needs and align with the priorities of organizations working on behalf of species and habitat conservation in Washington. We will use responses to help shape and prioritize key elements of the Plan. The SWAP is updated every 10 years and designed to be a blueprint to inform conservation planning within WDFW and also the broader conservation community in the State. Click this link (http://wdfw.wa.gov/conservation/cwcs/) for a one page overview.

Thank you in advance for taking the time to respond to this survey.

1. What is the name of your organization?

2. Your name and your position title?

3. What description best fits your organization?

- ☐ What description best fits your organization? Indian Tribe
- ☐ Non-governmental organization
- ☐ Coalition
- ☐ Public-private partnership
- ☐ State agency
- ☐ Local agency
- ☐ Federal agency

Other (please specify)

4. Which activities best describe the primary focus of your organization? (choose all that apply)

- ☐ Research

- [ ] Citizen science
- [ ] Restoration Projects
- [ ] Land trust
- [ ] Land Management
- [ ] Citizen Science
- [ ] Recreation
- [ ] Private land owner
- [ ] Working land owner

Other (please specify) ______

5. Please describe how the State Wildlife Action Plan could be value added to your organization. What would it need to do to support or enhance the work of your organization in a positive way?

6. Please indicate one to three priority intiatives or objectives of your organization (related to species or habitat conservation) in the next 3-5 year timeframe. Please be brief but specific enough so that we can assess how WDFW and the State Wildlife Action Plan might contribute to those objectives.

7. Please indicate which of the following are ways your organization either works with WDFW currently, or might in the future. Click all that apply.

- ☐ Please indicate which of the following are ways your organization either works with WDFW currently, or might in the future. Click all that apply. Share information on priorities for species and habitat conservation
- ☐ Use information in the State Wildlife Action Plan to develop joint projects on common priorities
- ☐ Collaborate on citizen science projects
- ☐ Collaborate on preparing outreach and education materials
- ☐ Provide public testimony or other support for State Wildlife Grants Program (e.g., attend the annual Teaming with Wildlife Fly-in Days)
- ☐ Contribute to landscape or regional conservation efforts (e.g. the Arid Lands Initiative)
- ☐ Provide specific expertise as needed to advance conservation objectives
- ☐ Other

8. What is your preferred way to comment or contribute to the development of the SWAP?

Track developments via web and comment when needed

- ☐ Periodic email updates
- ☐ 2-3 hour workshops to engage with staff and explore SWAP content
- ☐ Webinars to introduce elements of the SWAP and address questions
- ☐ WDFW presentations at events or meetings of my organizations

Other (please specify)

9. Is there anything else you'd like to tell us?

Thank you for taking our survey! Next

Appendix E

Prioritization Matrix

Description of the WDFW Prioritization Tool

The prioritization tool uses 34 different criteria to rank an action for the purpose of informing planning discussions and decisions. This tool first attempts to identify actions that are either an absolute priority (the expectation is that it be done and justification is required if it will not occur), or non-priority (meaning there are sufficient reasons to not take an action and if an action is taken it should be justified). All actions can also be scored using both weighted and standard criteria that, if applicable to the action, add value to its relative priority. Finally, the status of the species or ecosystem (the Resource Score) may also be added to the equation to allow that value to influence the priority ranking.

Step by Step Instructions

The italicized instructions below are found on the "Instructions" tab on the Prioritization Tool and describe how to complete the Priority Scoring spreadsheet found on the "Scoring Tool" tab. Figures D-1 to D-5 provide screen shots of the various tabs for illustration purposes only.

The tool is intended to prioritize all types of actions (even those that are not similar; e.g. a planning activity vs. a habitat improvement project); however, it may be more useful when evaluating similar actions (e.g. one type of species survey vs. another species survey).

Scoring:

Step 1	*Describe an Activity in Column A.*
Step 2	*Assign a Resource Score by determining Taxa or Ecological System Priority value (see Figure 5). If more than one applies, choose the highest ranking (lowest #).*
Step 3	*Record the value derived from Step 2 in Column AO of the ScoringTool tab*
Step 4	*Examine the ABSOLUTE PRIORITY, NON-PRIORITY, WEIGHTED PRIORITY, and STANDARD PRIORITY Columns in the ScoringTool tab; insert a "1" in all that apply. (See figures 1-4)*

Interpreting the Results:

Step 1	*Consider the overall Total Absolute Priority Score (Column H).*
Step 2	*Any action with a positive value in the Total Absolute Priority column should be treated as a high priority and justification should be developed if the activity will not be conducted or completed.*
Step 3	*Consider the Total Non-Priority Score (Column N).*
Step 4	*Any action with a positive value in the Total Non-Priority column should be treated as a very low priority and justification should be developed if the activity is to be conducted.*
Step 5	*Examine the Total Priority Score (AN) and the Combined Priority Score (AO).*
Step 6	*The Combined Priority Score is the Actions final priority score and should be compared to scores from other activities being evaluated.*
Step 7	*When making decisions, it may be useful to also compare just the Total Priority Scores to understand how the Resource Score embedded into the Combined Priority Score affected that score.*

Classifying Actions and Activities

This prioritization tool provides one means by which actions and activities that WDFW undertakes may be prioritized by scoring actions using the criteria described in the categories below.

Absolute Priority

If an action is linked to one or more absolute priority values, the action is assumed to be of highest priority and is required to be accomplished or justification must be provided for why it will not be accomplished.

- Statutory Requirement
- Legal Mandate (e.g. court order)
- Financial or Contract obligations (including match commitments for grants)
- Governor Priorities and Requests (e.g. Results Washington)
- Fish and Wildlife Commission Requests
- WDFW Director or Assistant Director Priorities and Requests (e.g. Conservation Initiative)

Figure E-1: Illustration of the Absolute Priority Scoring Tool

ABSOLUTE PRIORITY						TOTAL ABSOLUTE SCORE
Statutory Requirement	Legal mandate (e.g. court order)	Financial, or Contract Obligations (including Match commitments)	Governor Priorities and Requests (Results WA)	FWC Priorities and Requests	Director or Assistant Director Priorities and Requests (e.g. Conservation Initiative)	

Non-Priority

If an action or activity triggers one or more of these items it qualifies as a non-priority. In general, WDFW should not implement actions determined to be a non-priority without justification.

- Other entities will lead or are likely to conduct the actions with or without WDFW
- The cost of the project makes the action infeasible, including consideration of short- and long-term resource commitments
- The likelihood of success is so low that investing in the effort is not justifiable
- The action will result in significant risk to WDFW authorities or funding streams
- Action will result in higher priority conservation action not occurring

Figure E-2: Illustration of the Non-Priority Scoring Tool

NON-PRIORITY					TOTAL NON-PRIORITY SCORE
Other entities (USFWS, NOAA, Federal Land Managers, non-profits, land trusts, Partnerships, Citizen Science)will lead or are likely to perform the conservation actions with or without WDFW	The cost of the project makes the action infeasible, including consideration of short- and long-term resource commitments	The likelihood of success is so low that investing in the effort is not justifiable	Action will result in significant risk to WDFW authorities or funding streams	Action will result in higher priority conservation action not occurring	

All actions, but in particular those that have not been found to be either an absolute or a non-priority, may then be scored to determine their relative priority by evaluating them against several weighted and standard criteria.

Weighted Priority

Weighted priority are criteria that are considered to be particularly important when determining an actions priority. (See Figure D-3)

- Achieves conservation outcome that contributes to species recovery
- Achieves conservation outcome that maintains or restores ecological integrity
- External interests could impact WDFWs regulatory authorities or funding if WDFW does not engage in the action
- Action is a state, regional, national or international priority that WDFW has committed to support (NABCI/AFWA/WAFWA priorities)
- Achieves conservation necessary to preclude the need for listing or support down-listing or de-listing action at the Federal level, or mitigates the impacts of a listing (e.g. CCAA, SHA)
- Achieves conservation necessary to preclude the need for listing or support down-listing or de-listing action at the state level
- WDFW participation is essential to address an urgent conservation need (imminent threat) that will result in unacceptable harm or loss to the species or habitat
- Action or project is likely to maintain or develop a funding source or mechanism for diversity species conservation
- WDFW participation would foster partnerships or help maintain project and/or social/political support for WDFW
- Action can be shown to have long-term values when evaluated in climate change projections

Figure E-3: Illustration of the Weighted Priority Scoring Tool

WEIGHTED PRIORITY (INSERT "1" IN EACH APPLICABLE CELL; IT WILL BE MULTIPLED BY THE VALUE IN COLUMN Y)										TOTAL WEIGHTED PRIORITY SCORE
Achieves conservation outcome that contributes to species recovery	Achieves conservation outcome that maintains or restores ecological integrity	External interests could damage WDFWs regulatory authorities or funding if WDFW does not engage	State, regional, national or international priority that WDFW has committed to support (NABCI/AFWA/WAFWA priorities)	Achieves conservation necessary to preclude the need for Federal listing or likely to result in the species being listed (or downlisted) as threatened, or delisted; or mitigate the impacts of a listing (e.g. CCAA, SHA)	Achieves conservation necessary to preclude the need for State listing or likely to result in the species being listed (or downlisted) as sensitive, threatened, or delisted	WDFW participation is essential to address a pressing conservation need (imminent threat) that will result in unacceptable harm or loss to the species or habitat	Action or project likely to maintain or develop a long-term funding source or mechanism for diversity species conservation	Failure to participate would erode or prevent important partnerships or cause the collapse of a multi-partner or ongoing project and/or social/political support for WDFW	Action can be shown to have long-term values when evaluated in climate change projections	3
										0

Standard Priority

Criteria that contribute to an action's priority but have not been weighted (see figure 4).

- Fills an immediate or near-term critical information need
- Provides ecosystem, landscape level, or multiple SGCN species benefits
- Action will preclude the need for Critical Habitat designation on WDFW lands
- Action addresses a need in a Federal recovery plan
- Action addresses a need in a species-specific State management plan
- Action addresses a need in the SWAP
- Action maintains or develops a partnership or citizen science effort that will implement conservation actions and reduce future WDFW work load
- Yields expanded conservation capacity and/or significant reduction in conservation work load
- Action is likely to significantly inform the public on important species conservation and other diversity issues
- Facilitates special conservation agreements involving landowners (private or public)
- Contributes to conservation assessment and/or status review with a longer-term need
- Action will also meet other WDFW goals and objectives (e.g. recreation such as hunting, fishing, watchable wildlife; customer service; maintain workforce)

Figure E-4: Illustration of the Standard Priority Scoring Tool

STANDARD PRIORITY - (ENTER "1" IN EACH APPLICABLE CELL; IT WILL BE MULTIPLIED BY THE VALUE IN COLUMN AM)										TOTAL STANDARD PRIORITY SCORE
Fills an immediate or near-term critical information need	Provides ecosystem, landscape level, or multiple SGCN species benefits	Action will preclude the need for Critical Habitat designation on WDFW lands (may not be needed due to HCP)	Action addresses a need in a Federal recovery plan	Action addresses address a need in a species-specific State management plan (e.g. recovery, 2-year action)	Action addresses a need in the SWAP	Action maintains or develops a partnership or citizen science effort that will implement conservation actions and reduce future WDFW work load	Action is likely to significantly inform the public on important species conservation and other diversity issues	Contributes to conservation assessment and/or status review with a longer-term need or use horizon	Action will also meet other WDFW goals and objectives (e.g. recreation such as hunting, fishing, watchable wildlife; customer service; maintain workforce)	1
										0

Scoring Totals

All actions are evaluated against all Weighted and Standard criteria, which generates a combined priority score (Figure D-6). Each score may be further refined by including the Resource Score in the analysis. Resource Scores are determined by comparing the NatureServe State and Global Ranks for species or ecosystem (See Figure D-5).

Figure E-5: Assigning Resource Scores

Resource Priority value relative to NatureServe Status Rank Category

Taxa Priority Assignment = red digits (see **TaxaRankValues** tab for S and G values)

↑

	NatureServe Global Rank				
NatureServe State Rank	**G1**	**G2**	**G3**	**G4**	**G5**
S1	1	1	1	2	2
S2	x	2	2	3	3
S3		x	4	5	5
S4			x	6	6
S5 & SNA				x	7

If a taxon is a vagrant, limited occurrence, peripheral to Washington due to geographic/political boundaries, or otherwise irregular in contributing to WA biodiversity, it is Priority = 8

Habitat (Ecol. System) Priority = red digits

	Global Category				
State Category	**1**	**2**	**3**	**4**	**5**
1	1	1	1	2	2
2	x	2	2	3	3
3		x	4	5	5
4			x	6	6
5				x	7

1 = critically imperiled (at highest risk of extinction)
2 = imperiled
3 = vulnerable
4 = apparently secure
5 = secure

Figure E-6: Combined Priority Score

TOTAL STANDARD PRIORITY SCORE	**TOTAL PRIORITY SCORE**	**RESOURCE SCORE**	**=**	**COMBINED PRIORITY SCORE**
1				
Subtotal	**Subtotal**	Subtotal	=	TOTAL

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Organization of References

References are organized first by chapter, and then alphabetically. The "CODE" column indicates the appropriate source category for the reference, as identified and required by RCW 34.05.271.

These codes are as follows:

i. independent peer review; review is overseen by an independent third party
ii. internal peer review; review by staff internal to WDFW
iii. external peer review; review by persons that are external to and selected by WDFW
iv. Open review; documented open public review process that is not limited to invited organizations or individuals
v. Legal and policy document; documents related to the legal framework for WDFW, including but not limited to: (A) federal and state statutes, (B) court and hearings board decisions, (C) federal and state administrative rules and regulations; and (D) policy and regulatory documents adopted by local governments.
vi. Data from pimary research, monitoring activities or other sources.
vii. Records of best professional judgement of WDFW employees or other inidividuals
viii. Other: sources of information that do not fit into one of the categories identified above.

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2015 STATE WILDLIFE ACTION PLAN

Summary of responses to comments received during the public comment period
(August 11-September 11, 2015)

COMMENTS RECEIVED

We received 21 comments by email from external reviewers. Eleven were in support of adding Great Blue Heron, eight recommended a number of other species be added to Species of Greatest Conservation Need (SGCN); listed below), and the remainder raised a small number of other issues. For questions, more information, or the full text of comments received, please contact Penny Becker at penny.becker@dfw.wa.gov.

RESPONSE

Each of the comments and Washington Department of Fish and Wildlife (WDFW) responses are briefly summarized below. Comments are organized by the chapter they most closely correspond to. Where appropriate, we have referenced the page number where specific edits to the public review draft can be found.

Chapter 2 – State Overview

COMMENT	RESPONSE
Acknowledge recent habitat acquisitions	Information on recent habitat acquisitions and descriptions of two additional collaborative projects (Puget Sound Nearshore Ecosystem Restoration Project and the I-90 Snoqualmie Pass Project) were added to Chapter 2 (See pages 2-16, 2-24, and 2-26).
Include additional collaborative projects	

Chapter 3 – Species of Greatest Conservation Need

COMMENT	RESPONSE
Add a generic "**local native pollinator complex**" to cover the conservation needs of Washington State's approximately 600 species of native bees and other declining native pollinators.	We added text in the SGCN chapter (page 3-40) to emphasize the importance of this group of species and we outlined challenges to their conservation. We also edited the methodology and criteria section in Chapter 3 to clarify that we need data to be able to confirm that the species is in need of conservation – lack of information alone does not qualify a species as an SGCN. While State Wildlife Grants may not be utilized to fund the work requested by the commenter, WDFW will continue to work with our partners and to utilize other funds (such as Watchable Wildlife License Plate funds) as possible to bring attention to our state's important pollinators.
Combine Priority Habitats and Species (PHS) and SGCN lists.	We evaluated the option of combining these lists early in the SWAP development process and determined that each program serves unique purposes, and is oriented towards different audiences. Combining the lists would dilute the effectiveness of each and ultimately cause more confusion. WDFW will work to better clarify the purpose and functions of these lists for internal and external users.
Terminology confusing – eliminate "species of concern".	WDFW will evaluate the benefits of retaining this term as we move forward with implementation of the SWAP.

Chapter 3 – Species of Greatest Conservation Need: recommendations for adding specific species to the list.

While we greatly appreciate the comments and data provided by all emails received, we have not changed the SGCN list as published in the SWAP Public Review Draft at this time. We reviewed the current status and data available for each of the species noted below and determined that in each case there was no compelling indication of region-wide decline. Please see Chapter 3 of the final SWAP for the criteria used to assess which species should be on the SGCN list. We also note for reviewers that federal guidance allows WDFW to add a species to the SGCN list within the next ten years, if new data or evidence of declines becomes available. We will periodically assess the status of species and recommended new additions if necessary. Please note that the comments have been summarized in the table below.

Species	Rationale for not adding this species to the SGCN list at this time.
Acorn Woodpecker *Although newer to WA, it is still in need of conservation because of the overall decline in oak woodland habitat and its slow reproduction rate.*	This species was not included on the SGCN list because it is at the periphery of its range, and has recently expanded its range north into Washington. We do not have information as to why the species has expanded into Washington.
Black-backed Woodpecker *This species is highly dependent on conservation restrictions -- essentially unknown away from recent burned forests, it exists only where burned snags are projected from salvage logging.*	It seems likely that this species exhibits both functional and numerical responses to forest fires. As a result, the population likely changes in space and time at multiple spatial scales. The most productive areas are recent burned forests and when those areas are no longer suitable the species again responds (we assume) both functionally and numerically. When recently burned forests are no longer present in a particular landscape or are insufficiently large at least some of these woodpeckers move back to the closed-canopy forest. We are fully aware of research indicating that the species uses recently burned forests and that salvage harvest modifies habitat. We are unaware, however, of any data indicating that the species is experiencing a long-term population decline. This is currently a PHS species, and therefore WDFW has developed management recommendations for local governments, conservation groups and others to utilize for its continued conservation.
Ten native bumblebees White-shouldered bumble bee, *Bombus appositus* High country bumble bee, California bumble bee, *Bombus californicus (fervidus)* Yellow bumble Bee, *Bombus fervidus* Obscure bumble bee, *Bombus calignosus* Fernald cuckoo bumble bee, *Bombus fernaldae* Frigid bumble bee, *Bombus frigidus* Indiscriminate cuckoo bumble bee, *Bombus insularis* Forest bumble bee,	There *are* many native bee species, and unfortunately, like many insects, we know little regarding their distribution and abundance, or trends of either. Our SGCN assessment process consisted of evaluating NatureServe designated G1, G2, S1 and S2 species, and state and federally listed taxa, which included only one or two bees. We also used additional resources as available for SGCN assessments. For our assessments of bees, we relied heavily on data that did exist; the recent *IUCN Assessments for North American Bombus spp. (Bombus* genus includes all bumble bees), and phone discussion with the lead author of the document, Rich Hatfield, with The Xerces Society for Invertebrate Conservation. All *Bombus* occurring in WA categorized by IUCN as Vulnerable or at a higher level of endangerment were added to SGCN list, unless there were significant questions regarding status presented in the analysis or justification notes. IUCN assessments categorized the three bumble bee SGCN as Vulnerable (Western and Morrison's Bumble Bees) and Critically Endangered (Suckley Cuckoo Bumble Bee). Two species recommended by this commenter were also categorized Vulnerable (California and Obscure Bumble Bees), but had significant questions presented in the report regarding data confidence or other assessment values.

Species	Rationale for not adding this species to the SGCN list at this time.
Bombus sylvicola Half-black bumble bee, *Bombus vagans* Van Dyke's bumble bee, *Bombus vandykei*	Of the other eight species recommended for SGCN status by this comment, seven were categorized by IUCN as Least Concern, and one as Data Deficient.
Cascades Frog *Should be added because the USFWS has issued a 90-day finding that determined consideration for listing under the ESA was warranted.*	We know of no data indicating region wide, long-term population declines of Cascades Frogs. Cascades Frog depend on high elevation wetlands for breeding, and are potentially at risk from climate change - population status should be assessed over time.
Cassin's Auklet *Data not sufficient to remove.*	We have no information to indicate this species has experienced a population decline. Many seabirds are susceptible to changes in their food supply in response to changes in oceanic conditions. This can result in dynamic changes in species abundance. This is currently a PHS species, and therefore WDFW has developed management recommendations for local governments, conservation groups and others to utilize for its continued conservation.
Common Murre *Data not sufficient to remove.*	We have no information to indicate this species has experienced a population decline. Many seabirds are susceptible to changes in their food supply in response to changes in oceanic conditions. This can result in dynamic changes in species abundance. This is currently a PHS species, and therefore WDFW has developed management recommendations for local governments, conservation groups and others to utilize for its continued conservation.
Great Blue Heron *WDFW does not separately list the disappearing Pacific Great Blue Heron, the fannini subspecies found only in the Salish Sea, from the herodias subspecies found throughout our state. In 1976 there were ten nesting colonies of fannini in Thurston County. At last counting, in 2009, there were only five.*	The subspecies *fannini* is found throughout the "coastal" areas of western Washington (not just in the Salish Sea) and extends to Alaska. We are not aware of evidence that any populations within western Washington have declined. The 9,000 individuals in the Greater Puget Sound area in 2006 (as mentioned in one comment letter) does not appear to us to be a small number. Without a newer estimate showing a decline, this doesn't represent a significant concern. Some colonies do exist close to populated areas and seem to do well as long as human disturbance doesn't become excessive. Also, we note that the SWAP SGCN list focused on statewide or region-wide population status and trends, not county by county. This is currently a PHS species, and therefore WDFW has developed management recommendations for local governments, conservation groups and others to utilize for its continued conservation.
Harbor Porpoise *The harbor porpoise should be included in protective management until it is certain that its population is stable or increasing.*	Two sources indicate that harbor porpoises have been on the increase in the Washington portion of the Salish Sea over the last 15 to 20 years and that the species may now be at historically high population levels. These sources include one WDFW biologist that annually surveys the Salish Sea (Evenson) and Cascadia Research Cooperative (Calambokidis). Both data sets seem to show a very noticeable increasing trend in harbor porpoises since the 1990s. This is currently a PHS species, and therefore WDFW has developed management recommendations for local governments, conservation groups and others to utilize for its continued conservation.

Species	Rationale for not adding this species to the SGCN list at this time.
Pileated Woodpecker *At risk because it requires large, decayed snags for nesting and roosting.*	Breeding Bird Survey data indicate slight increases in Washington for both time periods reported (1966-2013 and 2003-2013). Confidence intervals for both time periods indicate that trends were not distinguishable from stability. Trends for the Northern Pacific Rainforest (BCR 5) were slightly down for both periods, and again the confidence intervals were not distinguishable from stability. This is currently a PHS species, and therefore WDFW has developed management recommendations for local governments, conservation groups and others to utilize for its continued conservation.
Vaux's Swift *Specifically regarding Vaux's swift, there is widespread evidence from numerous sources (e.g., BBS data; Bull 2003) that this species has been in decline in the northwest for some time.*	Breeding Bird Survey data indicate slight declines in Washington, British Columbia and the Northern Pacific Rainforest (BCR 5); however, all trends had confidence intervals indicating that trends were not distinguishable from stability. The trend for Oregon was a slight increase. We are aware of no monitoring data that rigorously demonstrates a population decline in this species in Washington. The trend in habitat loss in Washington since European settlement is acknowledged; most of that loss occurred prior to the beginning of the Breeding Bird Survey period, and trend in habitat loss is now much less. Although this was not a reason for not including Vaux's Swift as a SGCN, it is noteworthy that forests in lower and mid-elevation areas in Washington (e.g. nonfederal lands in the Puget Lowlands and southwestern Washington) will almost certainly improve as habitat for this species in the decades ahead, as forest buffers along fish-bearing streams mature and trees in those buffers attain the size and age where the structural conditions needed by swifts for roosting and nesting are present. This is currently a PHS species, and therefore WDFW has developed management recommendations for local governments, conservation groups and others to utilize for its continued conservation.
Western Yellow-bellied Racer	This species is considered extirpated in Washington and we have chosen not to include these species as SGCN.

Chapter 4 – Habitats of Greatest Conservation Need

COMMENT	RESPONSE
High alpine lakes are unique and should not be lumped into the Open Water formation.	We recognize that one of the weaknesses of the National Vegetation Classification is the lack of detail regarding aquatic systems. We are working to strengthen the aquatic components of the national vegetation classification, particular in terms of defining ecological systems and will incorporate these refinements as we work to implement the SWAP.
Listing habitat features next to each SGCN in that ecological system would make plan more useful to implementers. Consider using sources such as Johnson and O'Neill (2001) and expert department staff to bring more specificity to this section.	We added language in Chapter 4 (page 4-3) to indicate the habitat features based on the work of Johnson and O'Neill that were referenced throughout the plan in developing conservation actions for species.

COMMENT	RESPONSE
Terminology is confusing. Explain differences between PHS, HGCN, ESOC.	Additional clarification of the term Habitats of Greatest Conservation is provided in Chapters 2 and 4. This new language clarifies that for the purposes of the SWAP, Habitats of Greatest Conservation Need includes ecological systems of concern (those identified as imperiled) as well as those ecological systems considered especially important to SGCN. We have also clarified the differences between HGCN and PHS – namely that the lists of habitats contained within each were developed for difference purposes and different audiences.

Chapter 5 – Climate Change

COMMENT	RESPONSE
Eliminate stocking of high alpine lakes as a climate adaptation strategy. Fish in naturally-fishless systems reduce the abundance of larval amphibian populations.	The Department recognizes that in some cases stocking lakes in high alpine areas can have deleterious effects on native amphibian populations. The Department has several ways to minimize this potential negative effect. 1. The Department minimizes lakes where fish stocking occurs. There are thousands of high elevation lakes in Washington, of which less than 2,000 contain fish. Most high lakes, tarns, and ponds are fishless and no fish stocking occurs. In addition, many of the high lakes that are stocked are not good amphibian habitat. Amphibians prefer shallow, warm, productive high lakes and ponds, which in turn do not support fish stocking well. Fish stocking occurs in lakes that are steep sided and deep. Finally, the Department does not stock “new“ high lakes; stocking occurs only at lakes that have historically been stocked. 2. The Department has also put in place measures to reduce the deleterious effects of stocking where fish stocking does occur sympatric with native amphibian populations. The Department has a high lakes stocking objective to stock lakes on a rotational basis, only stock lakes where reproduction cannot occur (or if reproduction can occur then to use triploid fish), mostly stock fish native to the range except in a few places, and stock at low densities with single age classes. This ensures that forage does not become limited to trout that could shift to consuming amphibians and that on a rotational basis most stocked lakes are fishless or at exceptionally low fish densities over time. Most lakes are stocked on a 3 to 10 year rotation based on fishing pressure. This approach is based on best science and outlined in the National Park Service fish stocking Environmental Impact Statement. 3. Finally, the Department is partnering with USFS and other land management entities to ensure that fish stocking is done in a way that does not preclude movement by amphibians through high elevation waters. WDFW is in the initial planning stages of ensuring aquatic connectivity of fishless waters throughout public lands in the Cascades. The Department is also working on identifying lakes where fish communities are likely to lead to elevated predation on amphibians. The Department estimates there are likely only 300 or so lakes (of the 7,000) where this is an issue, and we are looking for innovative ways to deal with these lakes.

Chapter 6 – Monitoring and Adaptive Management

COMMENT	RESPONSE
Ecosystem monitoring, multi-species monitoring and monitoring little known species are rarely	Both of these suggestions will be considered during the implementation of the SWAP.

COMMENT	RESPONSE
funded – suggest small dedicated fund for these.	
WDFW should do an annual TRACS summary for the public.	

Appendix B – Potential Range and Habitat Distribution Maps

COMMENT	RESPONSE
WDFW should do a report to assess the accuracy of the maps over time.	The Potential Range and Habitat Distribution Maps are considered a work in progress and we intend to refine and update them over time as new information becomes available regarding species occurrence data.
Add an index that lists SGCN distribution by county, similar to PHS.	While we appreciate the suggestion to make the maps as useful as possible, we want to clarify that these maps are not intended to be used as a substitute for the PHS maps currently published by the Department.

Appendix E – Prioritization Matrix

COMMENT	RESPONSE
Scoring tool should be provided on line.	WDFW will consider these options during the implementation phase of the SWAP.
Provide a real world example of using the criteria.	