Northwest Environmental Advocates

LOWER COLUMBIA COHO SALMON ESU (*Oncorhynchus kisutch pop. 1*)

Conservation Status and Concern
Washington coho salmon populations in this ESU are dominated by hatchery-origin spawners, are not demonstrably self-sustaining, and considered at very high extinction risk.

Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend	Climate Vulnerability
Threatened	None	Yes	G4T2Q	SNR	Low/unknown	Moderate-high

Biology and Life History


Photo: WDFW

Coho salmon in this ESU exhibit 'early' (mid-August to September) and 'late' (late September to October) adult return timing, with peak spawning occurring in late October and in December to early January, for each type respectively. Spawning can extend through February. Historically, early-returning coho spawned in upper reaches of large rivers in lower Columbia sub-basin and in rivers upstream of Cascade Crest (approximately Bonneville Dam), and late-returning coho spawned in smaller rivers or lower reaches of large rivers, with timing adapted to annual flow regimes and elevation. Juveniles usually rear for over a year (e.g., 18 months) in freshwater and move throughout natal river as they grow; some may leave freshwater early and rear in estuarine areas. Most juveniles migrate seaward from March to June, predominately in April and May, during their second year. Sub-adults typically rear for about 18 months in the ocean, inhabiting coastal waters north and south of Columbia River mouth. Ocean rearing locality may be correlated with early and late return-timing types. Most adults are age three at spawning, and some return at age two after 5 to 7 months at sea.

Distribution and Abundance
This ESU includes coho salmon in Columbia River tributaries from its mouth up to and including Big White Salmon and Hood rivers and Clackamas River (Willamette sub-basin). Dams in several rivers significantly reduced or eliminated historical distribution. Of 24 historical populations, 17 are in Washington. Coho salmon from 12 Washington artificial propagation programs are included in the ESU. Data on abundance trends for Washington populations are generally only available from 2010 forward, and these show low abundance for wild-born coho overall.

Habitat
Adult coho salmon use mainstem and tributary habitats. They often hold in pools in lower river areas prior to rain events that allow access to smaller tributaries upstream. Spawners use stream reaches where gravel sizes are optimal for redd (nest) construction and egg survival. Coho fry use shallow, low velocity areas for rearing, such as stream edges and side channels. During their long-term freshwater rearing, juveniles may move to higher flow areas and disperse into areas inaccessible to adults. Juveniles most often occur in pool rather than riffle habitat. Intact riparian vegetation, in-stream large woody debris and natural floodplain structure are important for juvenile productivity and survival. Summer low-flow conditions may reduce rearing habitat in area and quality (elevated temperature). Optimal freshwater temperature range is 54 to 57^{o} F and temperatures over 77^{o} F may be lethal. Columbia River estuarine areas are used for feeding during seaward migration. Sub-adults rear in Pacific Ocean continental shelf areas predominately off of Washington and Oregon, and to lesser extent off British Columbia and California.

References

Ford, M. J. (ed.). 2011. Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-NWFSC-113, 281pp.

Myers, J., C. Busack, D. Rawding, A. Marshall, D. Teel. D. M. Van Doornik, and M. T. Maher. 2006. Historical population structure of Pacific Salmonids in the Willamette River and Lower Columbia River basins. NOAA Tech. Memo. NMFS-NWFSC-73, 311pp.

Lower Columbia Coho Salmon ESU: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
1	Fish and wildlife habitat loss or degradation	Riverine, riparian, floodplain, and estuarine habitats lost, modified or heavily degraded by agricultural, urban and residential development.	Restore natural instream habitat forming processes and hydrological functions, e.g., remove diking, channelization, water diversions; restore riparian vegetation. Restore estuarine habitats and processes.	Current insufficient	External
2	Agriculture and aquaculture side effects	Percent of hatchery-origin fish on spawning grounds is often higher than management goal. Threat is loss of natural productivity.	Manage and modify hatchery operations to achieve goals for percent hatchery fish on spawning grounds.	Current Sufficient	WDFW
3	Fish and wildlife habitat loss or degradation	Habitat loss and degradation due to dams, transportation crossings, culverts, water diversions, shoreline industrial uses.	Dam and barrier removal.	Current insufficient	External
4	Energy development and distribution	Threat is from dam operations that modify natural hydrological cycle and flows and restrict or eliminate fish passage.	Restore or maintain adequate passage and optimum flows for fish.	Current insufficient	External
5	Fish and wildlife habitat loss or degradation	Dams impede and prevent passage of adults and juveniles.	Fish passage facilities need to be added or improved in multiple localities.	Current insufficient	External
6	Overharvesting of biological resources	Annual fishery management processes are required.	Adequate harvest management planning and monitoring.	Current sufficient	Both

NOTE: Numbers are for reference only and do not reflect priority.

OZETTE SOCKEYE SALMON ESU (*Oncorhynchus nerka pop. 2*)

Conservation Status and Concern

Ozette sockeye salmon are at very low abundance compared to historic condition, and quantity and quality of adequate lake beach spawning habitat may be declining.

Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend	Climate Vulnerability
Threatened	Candidate	Yes	G5T2Q	SNR	Low/stable	Moderate

Biology and Life History

Photo: WDFW

Adult sockeye salmon return to Ozette River from April to July, and hold in Ozette Lake between April and January. Spawning, either on lake's beaches or in river and tributary creeks, occurs from October to January. Following emergence in March and April, juveniles migrate to Ozette Lake, where nearly all rear for about a year and then emigrate to the sea the following March through June. During lake rearing they feed on planktonic crustaceans (e.g. *Daphnia* spp.), benthic invertebrates and insects. Ocean distribution and behavior of sub-adults are not well-known, but young fish may use nearshore ocean areas and move offshore as they growth. Ocean rearing may last from 1 to 3 years, but majority rear for about 2 years before returning to spawn. Adult total age ranges from 3 to 5 years, with most being 4 years of age.

Distribution and Abundance

This ESU consists of one sockeye salmon population in Ozette River basin on Washington's Pacific coast. Historical abundance was very large, based on peak harvest values, and minimum viable spawning abundance goal for recovery is 35,500. Lowest abundances likely occurred in the 1960's and 1970's. Abundance estimates have been highly variable and uncertain, but methodologies have improved and average annual abundance of returning adults for a recent ten-year period was over 2,500. Current abundance is very low compared to historical levels.

Habitat

Ozette Lake is primary habitat for adults and juveniles. Adults hold in lake and spawn on lakeshore beaches, particularly Allen's Beach and Olsen's Beach. Spawning substrates vary from cobble/large gravel to coarse sand and silt, and groundwater upwelling sites appear to be favored spawning sites. Spawners also use tributaries to the lake (e.g., Umbrella Creek, Big River, Crooked Creek) and spawn in gravel riffles and glides and less commonly in pools and side channels. Juvenile reside and feed in the lake throughout their freshwater rearing stage. Migration distances to and from ocean through Ozette River are relatively short. Ocean rearing areas are not well-known, but nearshore and offshore North Pacific waters are likely used.

References

Ford, M. J. (ed.). 2011. Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-NWFSC-113, 281pp.

Haggerty, M. J., A. C. Ritchie, J. G. Shellberg, M. J. Crewson, and J. Jalonen. 2009. Lake Ozette Sockeye Limiting Factors Analysis. Prepared for Makah Indian Tribe and NOAA Fisheries in cooperation with Lake Ozette Sockeye Steering Committee, Port Angeles, WA. 565pp.

Ozette Sockeye ESU: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
1	Fish and wildlife habitat loss or degradation	No cities or towns impacts, but land use or other factors may be affecting quantity and quality of spawning habitats, such as lake beaches.	Research, survey or monitoring - habitat.		External
2	Resource information collection needs	Continue adult and juvenile monitoring.	Research, survey or monitoring - fish and wildlife populations.		External
3	Agriculture and aquaculture side effects	Management and monitoring of hatchery restoration program needs to be maintained.	Hatcheries (restoration).		External

NOTE: Numbers are for reference only and do not reflect priority.

LOWER COLUMBIA STEELHEAD DPS (*Oncorhynchus mykiss pop. 14*)

Conservation Status and Concern
Most populations are rated at high or very high extinction risk, and dams block several large areas of historic range. Habitat degradation and hatchery-related impacts are other limiting factors.

Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend	Climate Vulnerability
Threatened	Candidate	Yes	G5T2Q	SNR	Low/stable	Moderate-high

Biology and Life History

Photo: NOAA

Adults in this DPS exhibit winter and summer adult return timing. Winter-run steelhead in mature condition may begin entering natal rivers in early December; spawning occurs typically from early March to early June, with peak in late April/early May. Summer-run steelhead in immature condition begin entering natal rivers in early May and entry extends to October; they mature in freshwater and spawn in following calendar year from January to June, with peak in late February to early April. Adults usually survive spawning and migrate to sea. Some adults, especially females, spawn more than once. Juveniles rear in freshwater for 1 to 4 years, with most rearing for 2 years. Juveniles that migrate seaward do so predominately from April to June, with peak in May; some mature in freshwater without going to sea, more commonly in males than females. Ocean migration paths are not well-documented but sub-adults may rear in central North Pacific Ocean or Gulf of Alaska; rearing typically occurs for 1 to 3 years, with 2 years the most common. Total age at first return to spawn is usually 4 to 6 years.

Distribution and Abundance
This DPS includes steelhead in Washington and Oregon Columbia River tributaries from Cowlitz River up to Hood River. In Washington, there are 14 historical winter-run and five historical summer-run populations. Steelhead from four Washington hatchery propagation programs are included in DPS, but hatchery steelhead from non-native and non-local stocks are not. Dams in several rivers have significantly reduced or eliminated historical distribution. Other man-made barriers and habitat alterations further reduce distribution. Current abundance is low compared to historic. Recent analyses indicated that in Washington, only the Wind River summer-run population was considered viable, and most others were at very high or high risk levels.

Habitat
Adults use wide variety of freshwater habitats, spawning or holding in river mainstems and large and small tributaries. They migrate relatively far upstream in natal rivers compared to other salmonids and access is aided by flow conditions during migration timing. Redds (nests) are constructed in riffles and downstream margins of pools in streambeds where gravel sizes are optimal. Instream woody debris, boulders and stream bank structure provide important cover. Newly emerged juveniles use shallow gravel bed areas in riffles, among boulders, or near stream banks. As juveniles grow they move to higher water velocity areas and maintain individual territories for feeding. During long-term rearing, juveniles may move throughout watershed, using differing habitats in response to seasonal flow and temperature conditions. Instream cover is important for overwintering juveniles, and intact riparian

vegetation is essential for contributing woody debris, supporting invertebrate prey, and shading. Freshwater temperatures over 77° F are expected to be stressful or lethal. Columbia River mainstem is migration corridor. Central North Pacific Ocean and Gulf of Alaska may be marine rearing habitats.

References

Ford, M. J. (ed.). 2011. Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-NWFSC-113, 281pp.

Myers, J., C. Busack, D. Rawding, A. Marshall, D. Teel. D. M. Van Doornik, and M. T. Maher. 2006. Historical population structure of Pacific Salmonids in the Willamette River and Lower Columbia River basins. NOAA Tech. Memo. NMFS-NWFSC-73, 311pp.

Lower Columbia Steelhead DPS: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
1	Fish and wildlife habitat loss or degradation	Riverine, riparian, floodplain, and estuarine habitats lost, modified or heavily degraded by agricultural, urban and residential development.	Restore natural instream habitat forming processes and hydrological functions, e.g., remove diking, channelization, water diversions; restore riparian vegetation. Restore estuarine habitats and processes.	Current insufficient	External
2	Agriculture and aquaculture side effects	Percent of hatchery-origin fish on spawning grounds is often unknown, and thus it is uncertain if management goals are being met. Threat is loss of natural productivity and diversity.	Manage and modify hatchery operations to achieve goals for percent hatchery fish on spawning grounds.	Current sufficient	WDFW
3	Fish and wildlife habitat loss or degradation	Habitat loss and degradation due to dams, transportation crossings, culverts, water diversions, shoreline industrial uses.	Dam and barrier removal.	Current insufficient	External
4	Energy development and distribution	Threat is from dam operations that modify natural hydrological cycle and flows and restrict or eliminate fish passage.	Restore or maintain adequate passage and optimum flows for fish.	Current insufficient	External
5	Fish and wildlife habitat loss or degradation	Dams impede and prevent passage of adults and juveniles.	Fish passage facilities need to be added or improved in multiple localities.	Current insufficient	External

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
6	Resource information collection needs	Monitoring needed that will ascertain proportion of hatchery-origin spawners in annual spawning escapements.	Research, survey or monitoring - fish and wildlife populations.	Current insufficient	WDFW

NOTE: Numbers are for reference only and do not reflect priority.

MIDDLE COLUMBIA STEELHEAD DPS (*Oncorhynchus mykiss pop. 17*)

Conservation Status and Concern
Many populations are rated at high extinction risk. Dams impede passage and reduce or modify access to large areas of historic range, and other habitat degradation limits distribution and productivity.

Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend	Climate Vulnerability
Threatened	Candidate	Yes	G5T2Q	SNR	Intermediate/stable	Moderate

Biology and Life History

Photo: NOAA

Most adults exhibit summer return timing, but winter return timing occurs in several populations. Summer-run steelhead in immature condition begin entering freshwater in late spring, and travel to and enter natal tributaries through summer and fall; they mature in freshwater and spawn in following calendar year usually from early March to early June. Winter-run steelhead enter freshwater in mature condition and may enter natal rivers by early December; their spawn timing may coincide with that of summer-run steelhead. Adults usually survive spawning and migrate to sea afterwards. Some adults, especially females, spawn more than once. Juveniles rear in freshwater for 1 to 5 years, with most rearing for 2 years. Juveniles that migrate seaward do so predominately from March to June; some mature in freshwater without going to sea, more commonly in males than females. Ocean migration paths are not well-documented but sub-adults may rear in North Pacific Ocean or Gulf of Alaska, typically for 1 to 3 years, with 2 the most common. Age at first return to spawn usually ranges from 3 to 6 years.

Distribution and Abundance
Steelhead in this DPS occur in Washington and Oregon Columbia River tributaries upstream and exclusive of Wind River (Washington) and Hood River (Oregon), and downstream of Priest Rapids Dam, but excluding Snake River basin. In Washington, extant populations occur in Yakima, Touchet, Walla Walla, and Klickitat rivers and Rock Creek; a remnant White Salmon River population may recover due to dam removal. Dams in several rivers have significantly reduced or eliminated historical distribution. Distribution also is reduced by other man-made passage barriers and habitat alterations from agriculture and other development. Abundance has increased in some areas (Yakima Basin and Walla Walla River) but is low in others. Recent analyses rated a few populations as viable, but the DPS was rated as not viable overall.

Habitat
Adults use wide variety of freshwater habitats, spawning or holding in river mainstems and large and small tributaries. They migrate relatively far upstream in natal rivers compared to other salmonids and access is aided by flow conditions during migration timing. Redds (nests) are constructed in riffles and downstream margins of pools in streambeds where gravel sizes are optimal. Instream woody debris, boulders and stream bank structure provide important cover. Newly emerged juveniles use shallow gravel bed areas in riffles, among boulders, or near stream banks. As juveniles grow they move to higher water velocity areas and maintain individual territories for feeding. During long-term rearing, juveniles may move throughout watershed, using differing habitats in response to seasonal flow and

temperature conditions. Instream cover is important for overwintering juveniles, and intact riparian vegetation is essential for contributing woody debris, supporting invertebrate prey, and shading. Freshwater temperatures over 77° F are expected to be stressful or lethal. Columbia River mainstem is migration corridor and is greatly modified by dams and reservoirs. North Pacific Ocean and Gulf of Alaska may be marine rearing habitats.

References

Ford, M. J. (ed.). 2011. Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-NWFSC-113, 281pp.

Middle Columbia Steelhead DPS: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
1	Fish and wildlife habitat loss or degradation	Riverine, riparian, floodplain, and estuarine habitats lost, modified or heavily degraded by agricultural, urban and residential development.	Restore natural instream habitat forming processes and hydrological functions, e.g., remove diking, channelization, water diversions; restore riparian vegetation. Restore estuarine (lower Columbia River) habitats and processes.	Current insufficient	External
2	Fish and wildlife habitat loss or degradation	Habitat loss and degradation due to dams, transportation crossings, culverts, water diversions, other water extraction.	Dam and barrier removal.	Current insufficient	External
3	Energy development and distribution	Threat is from dam operations that modify natural hydrological cycle and flows and restrict or eliminate fish passage.	Restore or maintain adequate passage and optimum flows for fish.	Current insufficient	External
4	Fish and wildlife habitat loss or degradation	Dams impede and prevent passage of adults and juveniles.	Fish passage facilities need to be added or improved in multiple localities.	Current insufficient	External

NOTE: Numbers are for reference only and do not reflect priority.

PUGET SOUND STEELHEAD DPS (*Oncorhynchus mykiss pop. 37*)

Conservation Status and Concern

In 2011, most populations showed declining growth rates and extinction risks were relatively high overall, especially for central/south Puget Sound populations. Habitat degradation and poor early marine survival may be impeding productivity.

Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend	Climate Vulnerability
Threatened	None	Yes	G5T2Q	SNR	Low/declining	Moderate-high

Biology and Life History

Photo: NOAA

Adults exhibit winter and summer return timing. Winter-run are most common. Winter-run adults in mature condition may begin entering rivers in late November; spawning may occur from February to June with peak spawning in April or May. Summer-run adults return to rivers from May to October and mature in freshwater, with spawning occurring in following calendar year from January to May. Some populations contain adults of both return- types, and which likely overlap in spawn-timing. Other exclusively summer-run populations occur upstream of falls or cascades that exclude fish returning in winter due to flows. Adults usually survive spawning and migrate to sea afterwards. Some adults, especially females, spawn more than once. Juveniles rear in freshwater for 1 to 3 years, with most rearing for 2 years. Juveniles that migrate seaward do so predominately in April and May; some mature in freshwater without going to sea, more commonly in males than females. Juvenile mortality in Puget Sound may be relatively high. Ocean migration paths are not well-documented but sub-adults may rear in central North Pacific Ocean or Gulf of Alaska, typically for 1 to 3 years, with 2 years the most common.

Distribution and Abundance

This DPS includes steelhead in Washington watersheds draining to Puget Sound, Hood Canal, and the Strait of Juan de Fuca west to and including Elwha River. It includes 32 historical populations. Steelhead in several hatchery programs based on local wild broodstock are included in the DPS, but hatchery steelhead from non-native and non-local stocks are not. Dams in several rivers significantly reduced or eliminated historical distribution, and other man-made barriers (e.g. culverts) further reduce distribution. Current abundance is at very low level compared to historic estimates. Summer-run populations are generally small due to limited habitat and abundance trends are not well-monitored.

Habitat

Adult steelhead use wide variety of freshwater habitats, spawning in river mainstems and large and small tributaries. They migrate relatively far upstream compared to other salmonids and access is aided by flow conditions during their return timing. Redds (nests) are constructed in riffles and downstream margins of pools in streambeds where gravel sizes are optimal. Instream woody debris, boulders and stream bank structure provide important cover. Newly emerged juveniles use shallow gravel bed areas in riffles, among boulders, or near stream banks. As juveniles grow they move to higher water velocity areas and maintain individual territories for feeding. During long-term rearing, juveniles may move throughout watershed and use differing habitats in response to seasonal flow and temperature conditions. Instream cover is important for overwintering juveniles, and intact riparian vegetation is essential for contributing woody debris, supporting invertebrate prey, and shading. Freshwater temperatures over 77° F are expected to be stressful or lethal. Central North Pacific Ocean and Gulf of Alaska are likely marine rearing habitats.

References

Ford, M. J. (ed.). 2011. Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-NWFSC-113, 281pp.

Myers, J. M., J. J. Hard, E. J. Connor, R. A. Hayman, R. G. Kope, G. Lucchetti, A. R. Marshall, G. R. Pess, and B. E. Thompson. 2015. Identifying historical populations of steelhead within the Puget Sound distinct population segment. U.S. Dept. Commerce, NOAA Tech. Memo. NMFSNWFSC-128.

Puget Sound Steelhead DPS: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
1	Fish and wildlife habitat loss or degradation	Riverine, riparian, floodplain, estuarine, and nearshore-marine habitats lost, modified or heavily degraded by agricultural, urban and residential development.	Restore natural instream habitat forming processes and hydrological functions, e.g., remove diking, channelization, water diversions; restore riparian vegetation. Restore estuarine and nearshore marine habitats and processes.	Current insufficient	Both
2	Agriculture and aquaculture side effects	Percent of hatchery-origin fish on spawning grounds is often higher than management goal. Threat is loss of natural productivity.	Manage and modify hatchery operations to achieve goals for percent hatchery fish on spawning grounds.	Current sufficient	Both
3	Fish and wildlife habitat loss or degradation	Habitat loss and degradation due to dams, transportation crossings, culverts, water diversions, shoreline industrial uses.	Dam and barrier removal.	Current insufficient	External
4	Energy development and distribution	Threat is from dam operations that modify natural hydrological cycle and flows and restrict or eliminate fish passage.	Restore or maintain optimum flows for fish.	Current insufficient	External
5	Fish and wildlife habitat loss or degradation	Dams impede and prevent passage of adults and juveniles.	Fish passage facilities need to be added or improved in some localities.	Current insufficient	External

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
6	Climate change and severe weather	River scour and excessive sedimentation are threats from high flows and bank/hillsides erosion.	Restoration of forests and adequate forest management to protect channels, stream banks, and floodplains, and reduce effects of heavy rains and high flows.	Current insufficient	External

NOTE: Numbers are for reference only and do not reflect priority.

SNAKE RIVER BASIN STEELHEAD DPS (*Oncorhynchus mykiss pop. 13*)

Conservation Status and Concern
Extant populations are at moderate to high extinction risk. Dams impede passage, reduce access to large areas of historic range, and limit productivity. Proportions of hatchery-origin spawners are a concern.

Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend	Climate Vulnerability
Threatened	Candidate	Yes	G5T2T3Q	SNR	Low/stable	Moderate-high

Biology and Life History


Photo: NOAA

Adults in this DPS exhibit summer return-timing. They enter freshwater in immature condition in late spring, and travel to and enter natal tributaries through summer, fall, and in following spring if they hold through winter in mainstem reservoirs. They mature in freshwater and spawn from February to May in calendar year following Columbia R. entry. Adults usually survive spawning and migrate to sea afterwards. Some adults, especially females, spawn more than once. Juveniles may rear in freshwater for 1 to 3 years, with most rearing for 2 years. Juveniles that migrate seaward do so predominately from March through June; some mature in freshwater without going to sea, more commonly in males than females. Ocean migration paths are not well-documented but sub-adults may rear in North Pacific Ocean or Gulf of Alaska, typically for 1 to 3 years. Age at first return to spawn usually ranges from 3 to 6 years.

Distribution and Abundance
Steelhead in this DPS occur in Snake River tributaries in Washington, Oregon, and Idaho. Of 24 extant populations, two are entirely in Washington and two are in watersheds shared by Washington and Oregon. Historical populations likely occurred upstream of impassable Hells Canyon Dam. Asotin River abundance has been stable, but Tucannon River wild-born fish abundance has been low, and population was rated at high risk. Tucannon steelhead monitoring has revealed high proportions of non-local hatchery-origin and non-local wild-born adults entering river. If these remain and spawn, they may affect abundance and productivity of native population. Also, many Tucannon steelhead were found to bypass river during migration, hold in Snake River upstream of Lower Granite Dam, and a proportion did not return downstream (over two dams) to natal river. Populations partially in Washington were at viable or stable status.

Habitat
Adult steelhead use wide variety of freshwater habitats, spawning or holding in river mainstems and large and small tributaries. They migrate relatively far upstream in natal rivers and access is aided by flow conditions during migration timing. Redds (nests) are constructed in riffles and downstream margins of pools in streambeds where gravel sizes are optimal. Instream woody debris, boulders and stream bank structure provide important cover. Newly emerged juveniles use shallow gravel bed areas in riffles, among boulders, or near stream banks. As juveniles grow they move to higher water velocity areas and maintain individual territories for feeding. During long-term rearing, juveniles may move throughout watershed, using differing habitats in response to seasonal flow and temperature conditions. Instream cover is important for overwintering juveniles, and intact riparian vegetation is essential for contributing woody debris, supporting invertebrate prey, and shading. Freshwater

temperatures over 77^{o} F are expected to be stressful or lethal. Columbia and Snake rivers are migration corridors (long distances), and are greatly modified by dams and reservoirs. North Pacific Ocean and Gulf of Alaska may be marine rearing habitats.

References

Bumgarner, J. D., and J. T. Dedloff. 2011. Lyons Ferry complex hatchery evaluation: summer steelhead annual report 2008 and 2009 run year. Washington Department of Fish and Wildlife, Olympia, WA.

Ford, M. J. (ed.). 2011. Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-NWFSC-113, 281 pp.

Snake River Basin Steelhead DPS: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
1	Fish and wildlife habitat loss or degradation	Riverine, riparian, floodplain, and estuarine habitats lost, modified or heavily degraded by agricultural, urban and residential development.	Restore natural instream habitat forming processes and hydrological functions, e.g., remove diking, channelization, water diversions; restore riparian vegetation. Restore estuarine (lower Columbia River) habitats and processes.	Current insufficient	External
2	Fish and wildlife habitat loss or degradation	Habitat loss and degradation due to dams, transportation crossings, culverts, water diversions, other water extraction.	Dam and barrier removal.	Current insufficient	External
3	Energy development and distribution	Threat is from dam operations that modify natural hydrological cycle and flows and restrict or eliminate fish passage.	Restore or maintain adequate passage and optimum flows for fish.	Current insufficient	External
4	Fish and wildlife habitat loss or degradation	Dams impede and prevent passage of adults and juveniles.	Fish passage facilities need to be added or improved in multiple localities.	Current insufficient	External

5	Agriculture and aquaculture side effects	Percent of hatchery-origin fish on spawning grounds need to be well-monitored and managed so that management goals for wild fish productivity are met. Threat is loss of natural productivity and diversity.	Manage and modify hatchery operations to achieve goals for percent hatchery fish on spawning grounds.	Current sufficient	Both

NOTE: Numbers are for reference only and do not reflect priority.

UPPER COLUMBIA STEELHEAD DPS (*Oncorhynchus mykiss pop. 12*)

Conservation Status and Concern
Extant populations are rated at high extinction risk. Dams impede passage and reduce access to large areas of historic range, and limit productivity. Proportions of hatchery-origin spawners are a concern.

Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend	Climate Vulnerability
Threatened	Candidate	Yes	G5T2Q	SNR	Low/increasing	Moderate-high

Biology and Life History


Photo: NOAA

Steelhead in this DPS exhibit summer adult return timing. They enter freshwater in immature condition in late spring, and travel to and enter natal tributaries through summer, fall, and in following spring, if they hold through winter in mainstem reservoirs. They mature in freshwater and spawn from early March to mid-July in calendar year following Columbia River entry. Adults usually survive spawning and migrate to sea afterwards. Some adults, especially females, spawn more than once. Juveniles may rear in freshwater for 1 to 5 years, with most rearing for 2 years. Juveniles that migrate seaward do so predominately from March through June; some mature in freshwater without going to sea, more commonly in males than females. Ocean migration paths are not well-documented but sub-adults may rear in North Pacific Ocean or Gulf of Alaska, typically for 1 to 3 years. Total age at first return to spawn usually ranges from 3 to 6 years.

Distribution and Abundance
Steelhead in this DPS occur in Columbia River tributaries upstream and exclusive of Yakima River to the U.S./Canada border. Several tributaries upstream of impassable Chief Joseph and Grand Coulee dams could have historically supported additional populations. Steelhead in six artificial propagation programs are included in DPS. Dams, other man-made passage barriers and habitat alterations from land uses significantly reduced, modified or eliminated historical distribution. Barriers and land use impacts (e.g., irrigation) are being corrected in several rivers following Recovery Plan. Although total annual spawner abundance generally has increased in last 10 years, proportions of wild-born adults remain well below recovery goals. The four extant populations were last rated at high extinction risk.

Habitat
Adult steelhead use wide variety of freshwater habitats, spawning or holding in river mainstems and large and small tributaries. They migrate relatively far upstream in natal rivers compared to other salmonids and access is aided by flow conditions during migration timing. Redds (nests) are constructed in riffles and downstream margins of pools in streambeds where gravel sizes are optimal. Instream woody debris, boulders and stream bank structure provide important cover. Newly emerged juveniles use shallow gravel bed areas in riffles, among boulders, or near stream banks. As juveniles grow they move to higher water velocity areas and maintain individual territories for feeding. During long-term rearing, juveniles may move throughout watershed, using differing habitats in response to seasonal flow and temperature conditions. Instream cover is important for overwintering juveniles, and intact riparian vegetation is essential for contributing woody debris, supporting invertebrate prey, and shading. Freshwater temperatures over 77^{o} F are expected to be stressful or lethal. Columbia River mainstem is

migration corridor (long distance) and is greatly modified by dams and reservoirs. North Pacific Ocean and Gulf of Alaska may be marine rearing habitats.

References

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Upper Columbia Steelhead DPS: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
1	Fish and wildlife habitat loss or degradation	Riverine, riparian, floodplain, and estuarine habitats lost, modified or heavily degraded by agricultural, urban and residential development.	Restore natural instream habitat forming processes and hydrological functions, e.g., remove diking, channelization, water diversions; restore riparian vegetation. Restore estuarine (lower Columbia River) habitats and processes.	Current insufficient	External
2	Fish and wildlife habitat loss or degradation	Habitat loss and degradation due to dams, transportation crossings, culverts, water diversions, other water extraction.	Dam and barrier removal.	Current insufficient	External
3	Energy development and distribution	Threat is from dam operations that modify natural hydrological cycle and flows and restrict or eliminate fish passage.	Restore or maintain adequate passage and optimum flows for fish.	Current insufficient	External
4	Fish and wildlife habitat loss or degradation	Dams impede and prevent passage of adults and juveniles.	Add or improve fish passage facilities in multiple localities.	Current insufficient	External
5	Agriculture and aquaculture side effects	Percent of hatchery-origin fish on spawning grounds need to be well-monitored and managed so that management goals for wild fish productivity are met. Threat is loss of natural productivity and diversity.	Manage and modify hatchery operations to achieve goals for percent hatchery fish on spawning grounds.	Current sufficient	Both

NOTE: Numbers are for reference only and do not reflect priority.

BULL TROUT – COASTAL RECOVERY UNIT (*Salvelinus confluentus pop. 3*)

Conservation Status and Concern
Many of the Washington core area populations have unknown status. Bull Trout face threats from habitat degradation and fragmentation, poor water quality, and introduced non-native fish species.

Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend	Climate Vulnerability
Threatened	Candidate	Yes	G4T2Q	SNR	Unknown/unknown	Moderate-high

Biology and Life History


Photo: Roger Tabor, USFWS

Bull Trout in this DPS exhibit migratory (anadromous and amphidromous) and resident (adfluvial and fluvial) life history forms. They spawn in headwater streams and rivers from late summer to late fall, with falling water temperatures between 41 to 48° F., and may spawn each year or in alternate years. Eggs hatch in late winter or early spring. Fry emerge from gravel in April or May. Most information indicates that sexual maturity is attained in 4 to 7 years. They require colder waters than other trout species. Small Bull Trout eat terrestrial and aquatic insects, and shift to preying on fish as they grow larger. Large Bull Trout are primarily fish predators. Resident and migratory forms may be found together, and either form may produce offspring with either life history strategy.

Distribution and Abundance
Bull Trout in this Recovery Unit occur in Washington and Oregon watersheds west of the Cascade Mountains crest. In Washington, there are 16 core areas (habitat/population units) designated that include multiple populations. One historic core area, White Salmon River, was designated. Most core areas are in Puget Sound and Olympic Peninsula drainages, and two are in Columbia River drainages. Four core areas, Lower Skagit, Upper Skagit, Quinault River, and Lewis River, have been identified as current strongholds and likely have most stable and abundant populations in Recovery Unit. Bull Trout are reported as extirpated from White Salmon, lower Nisqually, and Satsop rivers, but these may not be only Washington extirpated localities in this Unit. Only a few populations are regularly monitored to estimate spawner abundance.

Habitat
Habitat includes deep pools in cold rivers and large tributary streams, often in moderate to fast currents, and large, cold lakes and reservoirs. Conditions that favor population persistence include stable channels, relatively stable stream flow, low levels of fine substrate sediments, high channel complexity with various cover types, and temperatures not exceeding about 59° F. Suitable migratory corridors between seasonal habitats and for genetic exchange among populations are needed. Spawning usually occurs in gravel riffles of small tributary streams, including lake inlet streams, with sites often associated with springs and upwelling groundwater. Optimum temperatures for incubation are about 36 to 39° F., and for juvenile rearing, about 45 to 46° F. Abundance of large woody debris and rubble substrate are important for rearing habitat.

References
USFWS. 2014. Revised draft recovery plan for the coterminous United States population of bull trout (*Salvelinus confluentus*). Portland, Oregon. xiii + 151pp.
WDFW. 2004. Washington State Salmonid Stock Inventory- Bull Trout/Dolly Varden. Washington Department of Fish and Wildlife, Olympia, WA. 449pp.

Bull Trout - Coastal Recovery Unit: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
1	Fish and wildlife habitat loss or degradation	Spawning and resident habitat has been destroyed or is threatened by urbanization, fisheries management activities, agriculture practices, mining, residential development, livestock grazing, dams and logging practices.	Even though many protective measures have taken place, currently-used spawning and resident habitat needs to be protected from degradation.	Current sufficient	Both
2	Invasive and other problematic species and genes	Introgression with hatchery-released eastern brook trout is a primary threat to Bull Trout in some waters.	Hatchery stocking of brook trout in drainages where Bull Trout are known to reside has been curtailed. Reducing existing numbers of brook trout where applicable/possible would be prudent.	Current insufficient	Both
3	Overharvesting of biological resources	Not 'accidental mortality' but intentional poaching of vulnerable fish during spawning season and other times of the year.	Increase law enforcement patrols of Bull Trout habitat during spawning season and close motor vehicle access to sensitive areas.	Current insufficient	Both
4	Climate change and severe weather	Potential climate change effects include increased water temperatures, which may have negative temporal and spatial impacts.	Restoration of forests and adequate forest management to protect riparian cover and restore landscape-level hydrology.		External

NOTE: Numbers are for reference only and do not reflect priority.

BULL TROUT – MID-COLUMBIA RECOVERY UNIT (*Salvelinus confluentus pop. 2*)

Conservation Status and Concern

Many of the Washington core area populations have unknown status. Bull Trout face threats from habitat degradation and fragmentation, poor water quality, and introduced non-native fishes.

Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend	Climate Vulnerability
Threatened	Candidate	Yes	G4T2Q	SNR	Unknown/unknown	Moderate

Biology and Life History

Photo: Roger Tabor, USFWS

Bull Trout in this DPS exhibit resident, adfluvial and fluvial life history forms. They spawn in headwater streams and rivers from late summer to late fall, with falling water temperatures between 41 to 48° F., and may spawn each year or in alternate years. Eggs hatch in late winter or early spring. Fry emerge from gravel in April or May. Most information indicates that sexual maturity is attained in 4 to 7 years. They require colder waters than other trout species. Small Bull Trout eat terrestrial and aquatic insects, and shift to preying on fish as they grow larger. Large Bull Trout are primarily fish predators. Resident and riverine migratory forms may co-occur, and each form produces offspring with either life history strategy.

Distribution and Abundance

Bull Trout in this Recovery Unit occur in Washington, Oregon and Idaho watersheds of the Columbia Basin east of the Cascade Mountains crest. In Washington, there are seven core areas (habitat/population units) designated, and Washington shares two other core areas with Oregon. Core areas may include multiple populations. The Okanogan River is recognized as foraging, migrating, and overwintering habitat. Bull Trout have been extirpated from Lake Chelan. The area upstream from Chief Joseph Dam is currently unoccupied by Bull Trout. Asotin Creek core area was as rated one of the least robust (most threatened). Some populations are regularly monitored, especially in the Yakima River core area, for spawner abundance, but total population abundance estimates are not made.

Habitat

Habitat includes deep pools in cold rivers and large tributary streams, often in moderate to fast currents, and large, cold lakes and reservoirs. Conditions that favor population persistence include stable channels, relatively stable stream flow, low levels of fine substrate sediments, high channel complexity with various cover types, and temperatures not exceeding about 59° F. Suitable migratory corridors between seasonal habitats and for genetic exchange among populations are needed. Spawning usually occurs in gravel riffles of small tributary streams, including lake inlet streams, with sites often associated with springs and upwelling groundwater. Optimum temperatures for incubation are about 36 to 39° F., and for juvenile rearing, about 45 to 46° F. Abundance of large woody debris and rubble substrate are important for rearing habitat.

References
Scholz, A. T. and H. J. McLellan. 2009. Field Guide to the Fishes of Eastern Washington. Eagle Printing, Cheney, Washington. 310pp.
USFWS. 2014. Revised draft recovery plan for the coterminous United States population of bull trout (*Salvelinus confluentus*). Portland, Oregon. xiii + 151pp.
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Bull Trout - Mid-Columbia Recovery Unit: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
1	Fish and wildlife habitat loss or degradation	Spawning habitat has been destroyed or is threatened by development, mining and logging practices.	Acquisition of cold headwater spawning habitat could be one solution to protecting it.	Current insufficient	Both
2	Overharvesting of biological resources	Spawning habitat and spawning fish have been damaged/poached-killed by individuals that have easy (motor vehicle) access to the stream's edge.	Increase law enforcement patrols of Bull Trout habitat during spawning season and close motor vehicle access to sensitive areas.	Current insufficient	Both
3	Invasive and other problematic species and genes	Introgression with hatchery-released eastern brook trout and brown trout is a primary threat to Bull Trout in some waters.	Hatchery stocking of brook trout and brown trout in drainages where Bull Trout are known to reside has been curtailed. Reducing existing numbers of these nonnatives where applicable/possible would be prudent.	Current insufficient	Both
4	Climate change and severe weather	Potential climate change effects include increased water temperatures, which may have negative temporal and spatial impacts.	Restoration of forests and adequate forest management to protect riparian cover and restore landscape-level hydrology.		External

NOTE: Numbers are for reference only and do not reflect priority.

INLAND REDBAND TROUT (*Oncorhynchus mykiss gairdneri*)

Conservation Status and Concern

Species is widespread, but some populations are at risk from non-native hatchery trout competition and interbreeding. Water quality issues threaten most locations, and barriers fragment populations.

Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend	Climate Vulnerability
None	None	Yes	G5T4	SMR	Unknown/unknown	Moderate-high

Biology and Life History

Inland Redband Trout have three history forms; resident, fluvial, and adfluvial. The resident form tends to live out its life in small tributaries and headwater streams. The fluvial form lives most of its life cycle in large rivers and streams before returning to its natal small tributary or headwater stream to spawn. The adfluvial form spends most of its life cycle in a lake or reservoir before returning to its natal headwater stream or tributary to spawn.

Photo: Courtesy USFWS

Distribution and Abundance

Inland Redband Trout historically occurred in the mid- and upper-Columbia River drainages east of the Cascade Mountains crest from above Celilo Falls (now submerged) to barrier falls on the Snake, Spokane and Pend Oreille rivers. It has been reported that current distribution in Washington is approximately 11 percent of the former range. Although population sizes are unknown for most of their Washington distribution, they are presumed stable.

Habitat

Inland Redband Trout prefer the clear, clean, cold water of headwater streams, creeks, small to large rivers, and lakes with lots of dissolved oxygen. Prime habitat consists of an array of riffles, pools, submerged wood, boulders, undercut banks, and aquatic vegetation. Winter habitat includes deep pools with extensive amounts of cover in third-order mountain streams. Summer surveys indicated that low-gradient, medium-elevation reaches with an abundance of complex pools are critical areas for production.

References

Behnke, R. J. 1992. Native trout of western North America. American Fisheries Society Monograph 6, Bethesda, MD. 275pp.

May, B. E., B. J. Writer, and S. Albeke. 2012. Redband Status Update Summary. Prepared by Wild Trout Enterprises, LLC, Bozeman, MT.

Muhlfeld, C. C., D. H. Bennett, and B. Marotz. 2001. Fall and winter habitat use by Columbia River redband trout in a small stream in Montana. N. Amer. Jour. Fisheries Management 21:170-177.

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Inland Redband Trout: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
1	Resource information collection needs	Although there are distribution data available, more are needed to accurately assess current status. Western Native Trout Initiative (WNTI) holds the communal database.	Continued survey data and genetic samples need to be collected.	Current insufficient	Both
2	Coordination/ Administration Needs	Complacency with both the current understanding of redband trout and the coordination of all agencies collecting data on redband trout could be considered a threat.	Continued and expanded coordination between agencies and tribes that collect redband trout data.	Current insufficient	Both
3	Invasive and other problematic species and genes	Introgression with hatchery-released non-native rainbow trout is a primary threat to Inland Redband Trout genetic integrity.	Stop hatchery stocking in waters where Inland Redband Trout are known to reside.	Current insufficient	Both
4	Agriculture and aquaculture side effects	Habitat degradation due to farming practices and crop production.	Farmer-targeted outreach to see if new crop culture practices could help reduce impact to fish populations.	Current insufficient	Both
5	Agriculture and aquaculture side effects	Habitat degradation due to ranching and stock-grazing practices.	Work with ranchers to fence riparian areas to prevent stock animals and waste from entering streams.	Current insufficient	Both
6	Energy development and distribution	Habitat loss due to dam construction.	Dam removal is unlikely. We identified the problem but there might not be a solution to this one.	Current insufficient	Both
7	Agriculture and aquaculture side effects	Habitat degradation due to farming practices and crop production.	Use existing plant culture practices that reduce impact to local fish populations.	Current insufficient	Both

NOTE: Numbers are for reference only and do not reflect priority.

WESTSLOPE CUTTHROAT TROUT (*Oncorhynchus clarkii lewisi*)

Conservation Status and Concern
Westslope Cutthroat Trout is stable and abundant in its range, but faces threats to its habitat and threats from genetic introgression.

Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend	Climate Vulnerability
Species of Concern	None	Yes	G4T3	SNR	Medium/stable	Low-moderate

Biology and Life History


Photo: Courtesy USGS

Westslope Cutthroat Trout have three life-history forms- adfluvial, fluvial, and resident, and all forms may occur within a single basin. Adfluvial fish live in lakes and spawn in its tributaries. They will occupy all lake habitats if no other trout species are present, otherwise, they segregate in nearshore, littoral areas. Fluvial fish reside in rivers and migrate to tributaries to spawn. Resident fish spend entire life in tributaries. Spawning occurs mainly in small headwater tributaries from March to July at water temperatures near 50°F. Fish tend to spawn in their natal stream. Fluvial and adfluvial forms usually return to rivers or lakes, but some remain in tributaries during summer. Juveniles begin to mature at age 3 years, but usually spawn for first time at age 4 or 5 years. Maturing adfluvial fish move to vicinity of tributaries in fall and winter, and begin to migrate upstream in spring. Adults and juveniles are opportunistic feeders, but primarily forage on insects and invertebrates.

Distribution and Abundance
In Washington, this species historically occurred in Lake Chelan and Methow River basins and in headwaters of Pend Oreille River, and was abundant in Lake Chelan Basin and Pend Oreille River. Naturally self-sustaining populations were found in almost every eastern-draining Cascade Mountain Columbia River subbasin (e.g., Yakima, Wenatchee, and Entiat) above 3,000 feet during 1990s surveys. Some of these may be due to stocking of hatchery fish into barren alpine lakes and streams. In western Washington, they have been reported in a few western Cascade Mountains drainages, such as tributaries to Skagit River and North Fork Skykomish River, South Fork Tolt River, and tributaries in Cowlitz Basin, but it is thought these resulted from releases of an eastern Washington hatchery stock. This species is abundant and stable in Washington.

Habitat
Habitats include small mountain streams, mainstem rivers, and large natural lakes. In rivers, adults prefer large pools and slow velocity areas. Stream reaches with numerous pools and some form of cover generally have highest densities. In lakes they often occur near shoreline areas. Preferred spawning habitat is small gravel substrates and mean water depths from 6.7 to 7.9 inches. Many fry disperse downstream after emergence. Juveniles of migratory populations may spend 1 to 4 years in natal streams, then move to a mainstem river or lake where they remain until they spawn. Juveniles tend to overwinter in interstitial spaces in stream substrates. Larger individuals congregate in deeper pools in winter. Resident fish tend to inhabit tributary shoreline areas in summer and overwinter in pools. Cool, clean, well-oxygenated water is essential.

References

Behnke, R. J. 1992. Native trout of western North America. American Fisheries Society Monograph 6. 275pp.
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Westslope Cutthroat Trout: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
1	Coordination/ administration needs	Complacency with both current understanding of species, and the coordination of all agencies collecting data on it could be considered a threat.	Continue to expand the distribution, habitat and genetic database for this species, with all interested agencies and tribes.	Current insufficient	Both
2	Invasive and other problematic species and genes	Even though many populations are stable, introgression with hatchery-released fish is a primary threat to species.	Stop hatchery stocking in waters where species is known to reside.	Current insufficient	Both
3	Fish and wildlife habitat loss or degradation	As with the other species, habitat fragmentation and degradation, due to various types of development is a constant threat to Westslope Cutthroat Trout.	Continued stewardship of spawning and residential habitat is needed to maintain current population rigor.	Current insufficient	Both

NOTE: Numbers are for reference only and do not reflect priority.

FRESHWATER FISH

BURBOT (*Lota lota*)

Conservation Status and Concern

Burbot are restricted to only 11 deep, cold-water lakes in Washington. Little is known about abundance, age structure, or productivity of any of the populations.

Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend	Climate Vulnerability
None	None	No	G5	S3	Unknown/unknown	Moderate

Biology and Life History

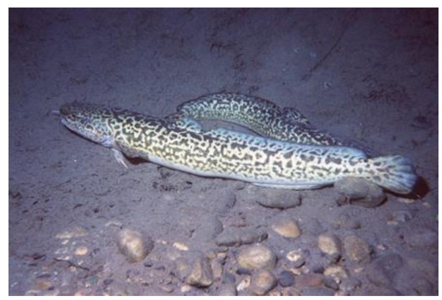

Photo: E. Keeley

Burbot is the only member of codfish family (*Gadidae*) inhabiting freshwater. Spawning occurs in late winter/early spring in Washington lakes when water temperature is about 35^{o}F. Individuals spawn annually or in alternate years. Eggs hatch in about a month. Young eat mainly immature aquatic insects, crayfish, mollusks, and other deepwater invertebrates. Larger individuals feed mostly on fishes. They usually become sexually mature in 3 to 4 years (males) or 4 to 5 years (females). Burbot are large with maximum length up to 33 inches, and maximum weight up to 33 pounds. The oldest Burbot recorded in Washington (gill net caught in Keechelus Lake, upper Yakima Basin) was age 19 years and was 29 inches long. Burbot over age 10 are common in Washington lakes. Little is known about population-specific abundance, age structure, or productivity.

Distribution and Abundance

Burbot are restricted to only 11 deep, cold-water lakes in Washington. Six lakes/reservoirs are in northern Columbia Basin (Osoyoos, Palmer, Chelan, Rufus Woods, Banks, and Roosevelt). Three lakes/reservoirs constructed on ancestral lakes are in upper Yakima Basin (Keechelus, Kachess and Cle Elum), and two lakes are in Pend Oreille region (Sullivan, Bead). No Burbot have been documented in western Washington. Of the eleven Washington lake populations evaluated in 1997, only one (Lake Roosevelt) was rated as "healthy", nine were rated as "unknown" status (relative to abundance and productivity), and one (Banks Lake) was rated "critical". This assessment 17 years ago did not provide adequate population trend data, or other data (size/age structure, productivity) needed for fishery management.

Habitat

In Washington, Burbot are found in deep (200 feet and greater), cold waters of lakes, reservoirs, and large rivers. In summer, stays close to the bottom in deep, cold waters, but may move into shallower water at night. Moves into shallow water in the winter when lakes are homothermous. In spawning, Burbot broadcast eggs usually over sand or gravel (sometimes silt) substrates in up to about 10 feet of water.

References
Bonar, S. A., L. G. Brown, P. E. Mongillo and K. Williams. 1997. Status of Burbot in Washington State. Wash. Dept. of Fish and Wildlife Research Report. 51pp.
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Burbot: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
1	Resource information collection needs	Inadequate data for population trend, size range, age structure, and productivity.	Research, survey or monitoring - fish and wildlife populations.	Current insufficient	WDFW
2	Fish and wildlife habitat loss or degradation	Reservoir water and habitat management effects on Burbot are unknown.	Research whether Burbot are entrained and killed by dam and reservoir facilities or management of those facilities and determine the effect of lack of fish passage on Burbot.		External
3	Overharvesting of biological resources	Burbot are harvested but no harvest assessment of impacts to populations are done.	Research, survey or monitoring - utilization.	Current insufficient	WDFW

NOTE: Numbers are for reference only and do not reflect priority.

LAKE CHUB (*Couesius plumbeus*)

Conservation Status and Concern

The status of this species is unknown and its major threat is habitat alteration.

Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend	Climate Vulnerability
None	Candidate	Yes	G5	S2S3	Unknown/unknown	Moderate

Biology and Life History

The Lake Chub spawns in spring and summer. Eggs hatch in about 10 days. They become sexually mature in their third or fourth year. They sometimes occur in large schools. This species may migrate up to 1 mile between separate spawning and non-spawning habitats. Lake Chub probably do not live more than 5 years and may grow as large as 6 inches.

Photo: K. P. Schmidt, National Park Service

Distribution and Abundance

In Washington, Lake Chub are found in the Columbia River system. They have been found in Cedar Lake (Stevens County) and the North Fork of Beaver Creek (Okanogan County). There was a documented occurrence west of the Cascade mountains in Twin Lake (Snohomish County) in the 1950s, but it is has likely been extirpated. Its distribution appears to be sparse in Washington and its status is unknown.

Habitat

This species occurs in varied habitats, including standing or flowing water, and large or small bodies of water. It is most common in gravel-bottomed pools and stream reaches, and along rocky lake margins. It is more common in lakes in the southern part of the range, mostly in rivers in the north (but in lakes if available). Often it occurs in shallows but may move into deeper parts of lakes in summer. Spawning occurs in river shallows, along rocky shores, in shoals of lakes.

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Lake Chub: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
1	Resource information collection needs	Listed as a "State Candidate Species" in Washington. Spotty distribution makes it vulnerable to population decline. Not enough data on distribution and status.	Periodic surveys to monitor status: increasing or declining.	Current insufficient	WDFW
2	Fish and wildlife habitat loss or degradation	Loss of habitat from human development merits further surveys and protection of some kind.	Periodic surveys to determine what habitat is currently being used and to document rate of habitat loss.	Current insufficient	WDFW
3	Resource information collection needs	A paucity of current information on distribution, status, and type of habitat use.	Field surveys are needed to determine current distribution, status and habitat use.	Current insufficient	WDFW

NOTE: Numbers are for reference only and do not reflect priority.

TUI CHUB (*Siphateles bicolor*)

Conservation Status and Concern
This species is confined to a small part of the Columbia Basin and its biggest threat is predation by non-native predators.

Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend	Climate Vulnerability
None	None	No	G4	S2S3	Unknown/unknown	Low-moderate

Biology and Life History

Photo: USDA Forest Service

Adult fish of all ages and sizes school together, while juveniles of same year class often school together. They inhabit lakes and slow-moving streams. They migrate to shallow water in the spring, but stay in deeper water in winter. Tui Chub first spawn at age 3 years and spawning takes place during late April to late June in areas with abundant aquatic vegetation. Multiple spawning by one female may be common. Eggs hatch in 10 to 12 days. Juveniles feed first on diatoms, rotifers, desmids, and other plankton, then transition to larger zooplankton. Adults feed on plankton, insects, crustaceans, and fish larvae and fry (including their own). In streams they will prey on various benthic organisms. Young fish are prey of large trout and introduced warm-water fish species.

Distribution and Abundance
Tui Chub are native to the Columbia Basin in central Washington, which is northernmost part of the species' range. In Washington, Tui Chub are confined to reservoirs, ponds, potholes, and warm, slow-moving reaches of lower Crab Creek, an upper Columbia River tributary. They are common to abundant in several Adams County interconnected lakes (McMannaman, Morgan, Half Moon, Hutchinson, and Shiner).

Habitat
This species usually occurs in weedy shallows of lakes or in mud- or sand-bottomed pools of slow-moving headwaters, creeks, and small to medium rivers. In lakes, Tui Chub spend winter in deep water, and move to shallow water in spring. In summer, this chub also occurs in deep water and in surface waters over deep water. Spawning usually occurs in shallow water where eggs settle to the bottom or adhere to aquatic vegetation. Young remain close to shore near heavy vegetation for most of summer.

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Tui Chub: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
1	Fish and wildlife habitat loss or degradation	Even though Tui Chub is known to overpopulate in some cases, lake rehabilitations have lowered numbers in Hutchinson and Shiner Lakes.	Need assessment surveys near Crab Creek and discontinue rehabilitations in waters where they are found.	Current insufficient	WDFW
2	Invasive and other problematic species and genes	Because of limited distribution, predation by non-native fish could have a significant impact in Washington.	It is difficult to control predation. Action unknown at this time.	Current insufficient	WDFW

NOTE: Numbers are for reference only and do not reflect priority.

LEOPARD DACE (*Rhinichthys falcatus*)

Conservation Status and Concern

The status of this species is unknown and it faces threats to its habitat.

Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend	Climate Vulnerability
None	Candidate	Yes	G4	S2S3	Unknown/unknown	Moderate-high

Biology and Life History

Leopard Dace spawn between May and July. Several males may spawn with one female. The average life span is probably 3 to 4 years, but could be as long as 7 years. The spawning habitat is probably similar to that of other dace that spawn in stream riffles. Young-of-the year feed on aquatic insect larvae. Yearlings feed on aquatic insects during the summer and in the fall switch to terrestrial insects. Adults feed on aquatic insect larvae, terrestrial insects, and earthworms.

Photo: from Wydoski and Whitney 2003

Distribution and Abundance

Population size and status are unknown. Distribution is spotty within the Columbia River Basin, and in Washington it is found in lower, mid, and upper Columbia River mainstem and tributaries, such as Yakima and Similkameen rivers, and in Snake River.

Habitat

Leopard Dace are usually found in streams, but can also occur in lakes. In streams, it prefers slow to moderate current and is associated with stone substrate covered by fine sediments. In creeks and small to medium rivers, the preferred habitat is flowing pools and gravel runs. They are usually found in slow-moving current, but in greater currents than used by Umatilla Dace, and in slower, deeper water than used by longnose dace. In lakes, Leopard Dace prefer rocky margins.

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Leopard Dace: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
1	Resource information collection needs	Listed as a "State Candidate Species" in Washington. Spotty distribution makes it vulnerable to population decline. Not enough data on distribution and status.	Periodic surveys to monitor status: increasing or declining.	Current insufficient	WDFW
2	Fish and wildlife habitat loss or degradation	Loss of habitat from human development merits further surveys and protection of some kind.	Periodic surveys to determine what habitat is currently being used and to document rate of habitat loss.	Current insufficient	WDFW
3	Resource information collection needs	A paucity of current information on distribution, status, and type of habitat use.	Field surveys are needed to determine current distribution, status and habitat use.	Current insufficient	WDFW

NOTE: Numbers are for reference only and do not reflect priority.

UMATILLA DACE (*Rhinichthys umatilla*)

Conservation Status and Concern

This species' status is unknown and it faces threats from human development and habitat alterations.

Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend	Climate Vulnerability
None	Candidate	Yes	G4	S2	Unknown/unknown	Moderate

Biology and Life History

Photo: Paul Mongillo, WDFW

Spawning probably takes place in early to mid-July. Food preferences are unknown, but presumed to be similar to other dace that feed primarily on insect larvae. The closely-related *R. osculus* is a benthic feeder and its young are primarily planktivores, while adults feed mainly on aquatic insects, fresh-water shrimp, plant material and zooplankton. Maximum size Umatilla dace can reach is about is 3 inches, and average life span is probably 3 to 4 years, but could be as long as 8 years.

Distribution and Abundance

This species occurs in Columbia Basin, east of Cascade Mountains crest. In Washington, it has been reported in the Columbia, Yakima, Okanogan, Similkameen, Kettle, Colville, and Snake rivers, and also may occur in the Methow and Wenatchee rivers. This species has experienced extensive habitat loss due to hydroelectric dams.

Habitat

Umatilla Dace are benthic fish that occur in relatively productive, lower elevation streams. They seem to prefer cover provided by cobbles and larger stones where current is fast enough to prevent siltation. They are most often captured along river banks at depths less than 3 feet, but larger fish tend to occupy deeper habitats. The species is absent from colder, mountain tributaries. They have been found in reservoirs where there is a rocky bottom and a noticeable current. Like Leopard Dace, Umatilla Dace usually occupy habitats with slower water velocity than those used by longnose dace, and Umatilla Dace adults use lower water velocities habitats than those used by Leopard Dace.

References

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Umatilla Dace: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
1	Resource information collection needs	Listed as a "State Candidate Species" in Washington. Spotty distribution makes it vulnerable to population decline. Not enough data on distribution and status.	Need more assessment surveys to determine current distribution and status and whether it merits a change in listed status.	Current insufficient	WDFW
2	Fish and wildlife habitat loss or degradation	Human-altered habitat has had a negative impact. Needs flowing water sufficient to maintain interspaces in rubble/cobble.	Need more assessment surveys to determine current distribution and type of habitat usage in Washington.	Current insufficient	WDFW

NOTE: Numbers are for reference only and do not reflect priority.

OLYMPIC MUDMINNOW (*Novumbra hubbsi)*

Conservation Status and Concern

Populations of this endemic species are confined to a very small lowland portion of western Washington and its biggest threat is loss of habitat.

Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend	Climate Vulnerability
None	Sensitive	Yes	G3	S2S3	Unknown/unknown	Moderate

Biology and Life History

Olympic Mudminnows are small, average length approximately 2.1 inches, and are not selective feeders, consuming annelids, crustaceans, insects, and mollusks. Spawning begins in late November, subsides during the winter months, then resumes in March and lasts until mid-June. Spawning sites are in shallow, low flow areas such as flooded areas adjacent to streams. Males maintain breeding territories. Eggs are adhesive and are deposited on aquatic vegetation; no parental care is given. Fry attach themselves to vegetation, using "gluing" head glands.

Photo: Julie Tyson, WDFW

Distribution and Abundance

The Olympic Mudminnow occurs only in Washington and its current range includes the southern and western lowlands of the Olympic Peninsula, Chehalis River Basin, lower Deschutes River drainage, and south Puget Sound west of the Nisqually River. Populations have also been observed in King and Snohomish counties within the Cherry Creek drainage, Peoples Creek drainage, and Issaquah Creek.

Habitat

This species has three main habitat requirements: water with little to no flow, several inches of soft mud substrate, and abundant aquatic vegetation. Its preferred habitat includes quiet waters with mud or dark bottoms, usually well-vegetated areas and areas under overhanging banks, especially in marshy streams and brownish water of bogs and swamps. They can also be found in low-lying marshes, roadside ditches, and vegetation-choked streams at lower elevations (sea level to 459 feet), but are intolerant of saltwater. This species does not occur in otherwise suitable areas that have introduced spiny-rayed fishes.

References

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Olympic Mudminnow: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
1	Fish and wildlife habitat loss or degradation	Classified as a "Sensitive Species" in Washington because of its restricted range, endemic to Washington and its habitat, vulnerable to destruction or negative change.	Continued surveys to confirm distribution and habitat use.	Current insufficient	WDFW
2	Fish and wildlife habitat loss or degradation	Loss of habitat from human development merits further surveys and protection of some kind.	Due to the amount of time passed since regular surveys, updated surveys to determine what habitat is currently being used and to document rate of habitat loss.	Current insufficient	WDFW
3	Resource information collection needs	Over ten years since the last surveys to determine distribution, status information, and type of habitat use.	More field surveys are needed to determine current distribution, habitat use and status.	Current insufficient	WDFW

NOTE: Numbers are for reference only and do not reflect priority.

MARGINED SCULPIN (*Cottus marginatus*)

Conservation Status and Concern
This species is confined to three rivers in southeastern Washington and faces threats to its habitat.

Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend	Climate Vulnerability
Species of Concern	Sensitive	Yes	G3	S1?	Medium/unknown	Moderate

Biology and Life History
Margined Sculpin is a benthic stream dwelling species. Spawning takes place in May to June. Eggs are deposited under rocks and the males actively guard the nest. Adults may reach about 2.5 inches in length. Food habits are unknown, but most sculpins feed on a variety of invertebrates, including aquatic invertebrates, terrestrial insects, and earthworms, and on young fish and fish eggs.

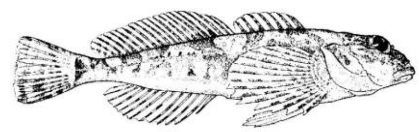

Image: WDFW

Distribution and Abundance
This species is endemic to Oregon and Washington, and occurs in headwater tributaries of Columbia Basin drainages in the Blue Mountains (northeastern Oregon and southeastern Washington). In Washington it occurs in headwaters of the Walla Walla, Touchet, and Tucannon rivers.

Habitat
Margined Sculpin primarily inhabit pools and slow-moving glides in headwater tributaries where water temperatures normally are less than 66^{o}F. Adults are usually found in deeper and faster water than juveniles. They are generally found in habitats with small gravel and silt substrates and avoid larger substrates (large gravel, cobble, boulders). However, this sculpin appears adaptable to a wide variety of currents and substrates. In areas where it is not competing with other sculpin species, it is found typically in moderate to rapid current on a rubble or gravel substrate.

References

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Margined Sculpin: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
1	Resource information collection needs	Listed as a "Sensitive Species" in Washington. Spotty distribution makes it vulnerable to population decline. Not enough data on distribution and status.	Periodic surveys to monitor status: likely declining.	Current insufficient	WDFW
2	Fish and wildlife habitat loss or degradation	Loss of habitat from human development merits further surveys and protection of some kind.	Periodic surveys to determine what habitat is currently being used and to document rate of habitat loss.	Current insufficient	WDFW
3	Resource information collection needs	Because of its very limited distribution in SE Washington, data on current population status, distribution and type of habitat use are lacking.	Field surveys are needed to determine current distribution, status, and habitat use.	Current insufficient	WDFW

NOTE: Numbers are for reference only and do not reflect priority.

MOUNTAIN SUCKER (*Catostomus platyrhynchus*)

Conservation Status and Concern

The status of this species is unknown and it faces threats to its habitat.

Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend	Climate Vulnerability
None	Candidate	Yes	G5	S2S3	Unknown/unknown	Low-moderate

Biology and Life History

Mountain Suckers are mostly riverine and spawn in riffles below pools in late spring-early summer when the water temperature is 52 to 66°F. Limited upstream spawning migrations may occur. Their diet is almost entirely algae and diatoms and they scrape food from rocks with their cartilaginous lower jaws. They, especially juveniles, also consume some invertebrates. They form schools, sometimes with other sucker species. Mountain Suckers are small and may reach a total maximum length of 9 inches.

Photo: from Wydoski and Whitney 2003

Distribution and Abundance

In Washington, this species is restricted to the Columbia River system. Mountain Suckers have been found in the Hanford Reach of Columbia River mainstem, and in Cowlitz, Yakima, Wenatchee, Palouse and Snake rivers. Population size and status are unknown.

Habitat

Mountain Suckers utilize river and stream areas of slow to moderate current and pools. Spawning occurs over gravel riffles. This sucker appears to prefer clear, cold creeks and small to medium rivers with clean rubble, gravel or sand substrate. It may favor pool-like habitats in some areas, and faster water in other regions. They are rarely found in lakes. Young fish usually inhabit slower moving waters in side channels, or weedy backwaters. In some areas, juveniles tend to occur closer to reservoirs than do adults. The species is most abundant where there is some form of cover in the water (used as daytime refuge). This sucker's presence may be a sensitive indicator of native fish and invertebrate assemblages.

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Mountain Sucker: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
1	Resource information collection needs	Listed as a "State Candidate Species" in Washington. Spotty distribution makes it vulnerable to population decline. Not enough data on distribution and status.	Periodic surveys to monitor status: increasing or declining and to confirm current distribution.	Current insufficient	WDFW
2	Fish and wildlife habitat loss or degradation	Loss of habitat from human development merits further surveys and protection of some kind.	Periodic surveys to determine what habitat is currently being used and to document rate of habitat loss.	Current insufficient	WDFW
3	Resource information collection needs	A paucity of current information on distribution, status, and type of habitat use.	Field surveys are needed to determine current distribution, status and habitat use.	Current insufficient	WDFW

NOTE: Numbers are for reference only and do not reflect priority.

SALISH SUCKER (*Catostomus sp. 4*)

Conservation Status and Concern
This species is only found in western Washington and faces threats from loss of habitat and degradation to water quality.

Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend	Climate Vulnerability
None	Monitor	No	G1	S1	Unknown/unknown	Moderate-high

Biology and Life History


Photo: Paul Mongillo, WDFW

Salish Suckers begin spawning in March or April, depending on the water temperature, and spawning can be prolonged until late August. Individuals first spawn at the end of their second year. This species is similar to other species of suckers in that it is a broadcast spawner and it deposits its eggs in riffles. Its life span is only 4 to 5 years in British Columbia, but older individuals are known from Washington. In British Columbia, the species typically co-occurs with juvenile coho salmon, cutthroat trout, and prickly sculpin. All of these species are capable of being significant predators of young Salish Suckers. Little is known about their diet, especially diet of juveniles. However, they probably have a diet similar to longnose suckers, which consists of a variety of benthic-dwelling aquatic invertebrates and occasionally fish eggs.

Distribution and Abundance
Salish Suckers are currently found only in western Washington and a few streams in British Columbia's lower Frazer Valley. In Washington, they have been found in six watersheds draining to Puget Sound (including Hood Canal), from Nooksack River to Lake Cushman in North Fork Skokomish River. Localities they have been reported in include several Nooksack Basin lowland creeks, Whatcom Lake, Skagit Basin including Sauk and Suiattle rivers, Stillaguamish Basin, including Twin, Chitwood, and Trout lakes, Deep Creek in Snohomish Basin, Green River, and Lake Cushman. Population size and status are unknown.

Habitat
Salish Suckers are benthic dwellers, and mainly found in lowland streams and associated ponds, and in off-channel sloughs and marshes of big rivers, as well as in lakes. They inhabit a variety of water velocities over silt and sand substrates, often in areas with instream vegetation and over-hanging riparian vegetation. They have a preference for slow-moving water in streams and most likely seek off-channel habitats during high stream-flows in winter and spring.

References

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Salish Sucker: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
1	Resource information collection needs	Loss of habitat from human development merits further surveys and protection of some kind.	Periodic surveys to monitor status: increasing or declining.	Current insufficient	WDFW
2	Agriculture and aquaculture side effects	Studies show fencing off streams will protect habitat from grazing animals.	B.C. studies show habitat enhancement, fencing and riparian plantings would be helpful.	Current insufficient	WDFW
3	Fish and wildlife habitat loss or degradation	Data show loss of habitat is causing population declines.	B.C. studies show habitat enhancement, fencing and riparian plantings would be helpful.	Current insufficient	WDFW

NOTE: Numbers are for reference only and do not reflect priority.

PYGMY WHITEFISH (*Prosopium coulteri*)

Conservation Status and Concern

Pygmy Whitefish status in Washington is unknown and it faces threats to habitat and water quality.

Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend	Climate Vulnerability
Species of Concern	Sensitive	Yes	G5	S1S2	Unknown/unknown	Low-moderate

Biology and Life History

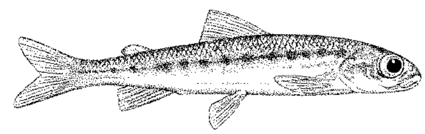

Image: WDFW

Slow growth, low fecundity and short life cycle characterize Pygmy Whitefish. They frequently are found in large schools of several thousand fish in both rivers and lakes. They spawn at night from late summer to early winter depending on the geographic location and elevation. Spawning occurs in stream riffles or along lake shorelines. Female fecundity ranges from 200 to 1,000 eggs. Average life span is 4 to 7 years, and size is usually less than 6 inches long. In general, males mature earlier and die earlier than females. Diet is primarily zooplankton, but may include macroinvertebrates, crustaceans and fish eggs. This species is considered a glacial relict, is one of the most primitive of coregonines, and has greatest discontinuous range of any North American freshwater fish.

Distribution and Abundance

Washington is at the southern end of Pygmy Whitefish's range. Historically they were known to have occurred in 15 Washington lakes. They currently inhabit nine lakes: Lake Chelan (Chelan County), Crescent Lake (Clallam County), Lake Chester Morse (King County), Lake Cle Elum, Lake Kachess, and Keechelus Lake (Kittitas County), Lake Osoyoos (Okanogan County), and Bead Lake and Lake Sullivan (Pend Oreille County). The six lakes they have been extirpated from are: North Twin Lake (Ferry County), Buffalo Lake (Okanogan County), Diamond Lake, Horseshoe Lake, and Marshall Lake (Pend Oreille County), and Little Pend Oreille Lakes (Stevens County). Population sizes and trends are unknown. They may co-occur with other whitefish species.

Habitat

Pygmy Whitefish normally occupy deep, unproductive lakes where the water temperatures are 50°F or lower, but there have been a few cases where this species was found in small shallow and more productive lakes, and they can also be found in streams. Common in lakes and flowing waters of clear or silted rivers in mountain areas; in western lakes, occurs in waters usually less than 20 feet deep, not changing depth seasonally. Spawners use coarse gravel substrates in shallow areas of streams or lakes.

References

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Pygmy Whitefish: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
1	Resource information collection needs	Classified as a "Sensitive Species" in Washington.	Periodic surveys to monitor status: increasing or declining.	Current sufficient	WDFW
2	Invasive and other problematic species and genes	It is likely that non-native fish are partially responsible for decline in numbers.	Collection of diet data from other species would help confirm or deny predation on species.	Current insufficient	WDFW

NOTE: Numbers are for reference only and do not reflect priority.

REFERENCES

SECTION A: Alphabetical list of species

SECTION B: Explanation of Terms

Conservation Status Table

Federal Status
Refers to legal designations under the Federal Endangered Species Act (listed as Endangered, Threatened, or Candidate species, or designated as a Sensitive species).

State Status
The Washington Fish and Wildlife Commission has classified 46 species as Endangered, Threatened or Sensitive, under WAC 232-12-014 and WAC 232-12-011. Other designations include Candidate and Monitor.

PHS (Priority Habitats and Species Program)
A species listed under the PHS program is considered to be a priority for conservation and management and requires protective measures for survival due to population status, sensitivity to habitat alteration and/or tribal, recreational or commercial importance. Management recommendations have been developed for PHS species and habitats, and can assist landowners, managers and others in conducting land use activities in a manner that incorporates the needs of fish and wildlife.

Global (G) and State (S) Rankings: Refers to NatureServe status rankings provided by the Natural Heritage Program. These conservation status ranks complement legal status designations and are based on a one to five scale, ranging from critically imperiled (1) to demonstrably secure (5). The global (G) and state (S) geographic scales were used for the SGCN species fact sheets. For more on the methodology used for these assessments, please see: Methodology for Assigning Ranks - NatureServe.

State Rank: characterizes the relative rarity or endangerment within the state of Washington.
S1 = Critically imperiled
S2 = Imperiled
S3 = Rare or uncommon in the state – vulnerable
S4 = Widespread, abundant, and apparently secure i
S5 = Demonstrably widespread, abundant, and secure in the State
SA = Accidental in the state.
SE = An exotic species that has become established in the state.
SH = Historical occurrences only are known, perhaps not verified in the past 20 years, but the taxon is suspected to still exist in the state.
SNR or = Not yet ranked. Sufficient time and effort have not yet been devoted to ranking of this taxon.
SP = Potential for occurrence of the taxon in the state but no occurrences have been documented.
SR = Reported in the state but without persuasive documentation which would provide a basis for either accepting or rejecting the report (e.g., misidentified specimen).
SRF = Reported falsely in the state but the error persists in the literature.
SU= Unrankable. Possibly in peril in the state, but status is uncertain. More information is need.
SX = Believed to be extirpated from the state with little likelihood that it will be rediscovered.

SZ = Not of conservation concern in the state.

Qualifiers are sometimes used in conjunction with the State Ranks described above:
B - Rank of the breeding population in the state.
N - Rank of the non-breeding population in the state.

Global Rank: characterizes the relative rarity or endangerment of the element world-wide.
G1 = Critically imperiled globally
G2 = Imperiled globally
G3 = Either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range - vulnerable
G4 = Widespread, abundant, and apparently secure globally
G5 = Demonstrably widespread, abundant, and secure globally, though it may be quite rare in parts of its range
GH = Historical occurrences only are known, perhaps not verified in the past 20 years, but the taxon is suspected to still exist somewhere in its former range.
GNR = Not yet ranked. Sufficient time and effort have not yet been devoted to ranking of this taxon.
GU = Unrankable. Possibly in peril range-wide but status uncertain. More information is needed.
GX = Believed to be extinct and there is little likelihood that it will be rediscovered.

Qualifiers are used in conjunction with the Global Ranks described above:

Tn Where n is a number or letter similar to those for Gn ranks, above, but indicating subspecies or variety rank. For example, G3TH indicates a species that is ranked G3 with this subspecies ranked as historic.

SECTION C: Full List of References

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State Wildlife Action Plan Update

Appendix A-5

Species of Greatest Conservation Need

Fact Sheets

INVERTEBRATES

Conservation Status and Concern

Biology and Life History

Distribution and Abundance

Habitat Needs

Stressors

Conservation Actions Needed

Washington Department of Fish and Wildlife
2015

Appendix A-5
SGCN Invertebrates – Fact Sheets

Table of Contents

What is Included in Appendix A-5

Introduction
Appendix A-5 is one component of the State Wildlife Action Plan (SWAP) Update, and contains information about invertebrates included in our Species of Greatest Conservation Need (SGCN) list for 2015. Included are fact sheets for each of the invertebrates identified as SGCN in the 2015 SWAP. The information provided includes a summary of the conservation concern and conservation status, description distribution and habitat, climate change sensitivity and an overview of key threats and conservation actions needed.

What it means to be an SGCN
The SGCN list includes both animals that have some form of official protection status and those which may be in decline, but are not yet listed as part of either the Federal or State Endangered Species program. One of the purposes of the SWAP is to direct conservation attention to species and habitats *before* they become imperiled and recovery becomes more difficult and costly. Presence on this list does not necessarily mean that conservation attention will be directed towards the animal; rather, that conservation actions for the species are *eligible* for State Wildlife Grants funding, and may be more competitive for other grant programs. It also raises the profile of an animal to a wide audience of conservation partners and may encourage other organizations to initiate projects that may benefit the species.

Climate Vulnerability
Please see Chapter 5 for an explanation of the methodology used to assess climate vulnerability. For a full list of all the SGCN ranks, including a narrative description of sensitivity and references, please see Appendix C.

Explanation of terms used in the document
Please see Section B (page 113) for a description of terms and abbreviations used in this document.

Alphabetical List of Species
For an alphabetical list of all the invertebrates included, please see Section A (page 110).

References
References are provided separately with each fact sheet, and also collectively for all SGCN invertebrates in the REFERENCES section at the end of this document.

MILLIPEDE

LESCHI'S MILLIPEDE (*Leschius mcallisteri*)

Conservation Status and Concern

Very little is known of this cryptic species, which was discovered and identified in 2004. It has only been detected within a small area in Thurston County.

Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend	Climate Vulnerability
None	Candidate	Yes	GNR	SNR	Unknown/unknown	N/A

Biology and Life History

This species was discovered and designated as a new genus and species in early 2004. No studies have been conducted.


Photo: W. Leonard

Distribution and Abundance

Six males and seven female paratypes were collected in February 2004 at and close by McAllister Springs near Olympia, WA. The collection area is located upstream of the Nisqually Wildlife Refuge and just downslope of a housing development situated on a bluff. More recent surveys at the type locality detected several individuals of the species. Actual total distribution of the species is unclear. It has not been detected elsewhere, but the species is cryptic and may be more widely distributed.

Habitat

Specimens were collected in leaf litter along a steep, east-facing slope in the lower Nisqually River Valley. The site was vegetated by mature second-growth forest dominated by bigleaf maple (*Acer macrophylum*), red alder (*Alnus rubrum*), western red-cedar (*Thuja plicata*), and western swordfern (*Polystichum munitum*). It appears to be limited to leaf litter in forest bottoms and perennial springs.

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W. Leonard, WSDOT, pers.comm.
K. McAllister, WSDOT, pers.comm.

Leschi's Millipede: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
1	Resource information collection needs	Only a handful of individuals have been found in a localized area with a specific combination of habitat features	Need to establish baseline survey effort beyond current known locations in areas with similar habitat features	Nothing current - new action needed	Both
2	Fish and wildlife habitat loss or degradation	Development on bluff above site location in Nisqually Valley. Area in which *L. mcallisteri* was found is probably private land	Investigate possibility of extending area protection	Nothing current - new action needed	External

NOTE: Numbers are for reference only and do not reflect priority.

MAYFLIES (Ephemeroptera)

Conservation Status and Concern

These mayfly species are generally rare and have very restricted distributions. Mayflies are very sensitive to pollution, and as such are usually only found at high quality, minimally polluted sites. Mayflies are a commonly used index of water quality and aquatic ecosystem health.

COMMON NAME (Scientific name)	Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend
[unnamed] (*Cinygmula gartrelli*)	None	None	No	G2G3	SNR	Low/unknown
[unnamed] (*Paraleptophlebia falcula*)	None	None	No	G1G2	SNR	Low/unknown
[unnamed] (*Paraleptophlebia jenseni*)	None	None	No	G2G4	SNR	Low/unknown
[unnamed] (*Siphlonurus autumnalis*)	None	None	No	G2G4	SNR	Low/unknown

CLIMATE VULNERABILITY RANKING	
Common Name (Scientific name)	Ranking
[unnamed] (*Cinygmula gartrelli*)	Low-moderate
[unnamed] (*Paraleptophlebia falcula*)	Low-moderate
[unnamed] (*Paraleptophlebia jenseni*)	Low-moderate
[unnamed] *(Siphlonurus autumnalis)*	Low

Biology and Life History

All mayflies are aquatic in their developmental stages. Their lifespan is spent almost entirely undergoing numerous molts. Larval existence is usually three to six months, but can be as short as two weeks or as long as two years. The nymphs are generalists, moving over stones and weeds to graze off bacteria, collecting from sediments or feeding on detritus. Most species are feeders or scrapers. Adults do not eat; they have nonfunctional digestive systems. Unlike most insects, the mayfly typically has two winged stages. It is the only existing insect that molts after getting functional wings. The first stage, the subimago, is a subadult stage typically found perched on shoreline vegetation; it lasts from four minutes to 48 hours (correlated with the lifespan of the species' adult stage). Soon after it is formed (in most species), the subimago molts to form the imago, the true adult or

Siphlonurus lacustris, a close relative of S. autumnalis. Photo: Hectonichus reproductive stage. Both subimagos and adults tend to remain along banks at emergence sites. Mayfly eggs are eaten by snails and caddisfly larvae. The nymphs may be eaten by fish, frogs, birds, flies, or water beetles. The subimagos are eaten by fish, birds, dragonflies, water beetles, or other predatory insects. Mating occurs in a swarm, and the eggs are laid as the female skims the water. The eggs sink to the bottom, and develop sticky substances or adhesive disks, depending on the species. Some species are parthenogenic. Adults of most species are short-lived (less than two hours to three days). Some species emerge in the spring while others dominate in autumn. Mayfly dispersal is limited in the larval stage by drainage systems and in adult stages by relatively short life spans and weak flying ability of gravid females. Dispersal at the population level has been little studied. Adult dispersal ability has not been extensively studied; however, several characteristics appear to limit occurrences to a short distance, including weak flying ability, extremely short life cycle, and tendency to remain in the area of emergence. This may partly account for the wide range of variability in some species, since once a population becomes established there is little opportunity for exchange of genetic materials with populations in other drainage systems.

Distribution and Abundance

***Cinygmula gartrelli*:** In Washington, this species occurs in the Ohanapecosh River, Mt. Rainier National Park, Lewis County; and Huckleberry Creek and Ipsut Falls in Mt. Rainier National Park, Pierce County. It was also recently found in Oregon in the Etolius River, Jefferson County.

***Paraleptophlebia falcula*:** In Washington, this rare species occurs in the South Fork Walla Walla River. In Oregon, it occurs in few historical sites in Benton and Union Counties with new localities in South Fork Walla Walla River, Umatilla County.

***Paraleptophlebia jenseni*:** This species is only known from Badger Gulch, Holter Gulch, and Rock Creeks in Klickitat County.

***Siphlonurus autumnalis*:** In Washington, this species occurred historically in Clallam, Grays Harbor, Jefferson, Lewis, and Pierce Counties; it was recently collected in Clallam County.

Habitat

Some mayflies species have very specific requirements. They are most commonly found on firm substrate in streams and lake littoral zones, but some are adapted for soft substrate. Mayfly nymphs are usually microhabitat specialists. Each species survives best on a specific substrate at a certain depth under water with a certain amount of wave action. Some species generally live in medium to large streams. Other species burrow into soft areas where flow is slower, or in areas of lakes and rivers where deposits occur; the particular substrate and burrow depends on the genus. The primitive habitat of mayflies is lentic (still water), even though most extant mayflies live in lotic (flowing water) environments.

***C. gartrelli*:** This species was found at high-altitude creeks, falls, and rivers in Mt. Rainier National Park.

***P. falcula*:** The genus often prefers moderate to fast streams with sand, gravel and detritus substrates.

***P. jenseni*:** *P. jenseni* is rare and has only been found in one substantial, fast running creek and two of its small, rocky, transient tributaries.

***S. autumnalis*:** This species is associated with medium to large rivers, and has been taken from rocky but somewhat quiet edgewaters along relatively large rivers in the Northwest. It has also been collected at a cold, spring brook in Montana.

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Mayflies: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
1	Resource information collection needs	Lack of data on current status and distribution	Determine distribution, population status	Current insufficient	Both
2	Climate change and severe weather	Potential for streams drying up	Determine distribution, population status	Current insufficient	Both
3	Fish and wildlife habitat loss or degradation	Water quality is of extreme importance to aquatic insects	Protect riparian habitats	Current insufficient	Both

NOTE: Numbers are for reference only and do not reflect priority.

DRAGONFLIES and DAMSELFLIES

Family Gomphidae: CLUBTAIL DRAGONFLIES

Conservation Status and Concern

These three dragonflies in the Gomphidae family are SGCN in Washington due to the small number of isolated populations and continued threats to their habitat.

COMMON NAME (Scientific name)	Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend
Columbia Clubtail (*Gomphus lynnae*)	None	Candidate	Yes	G1	S1	Low/unknown
Pacific Clubtail (*Gomphus kurilis*)	None	Candidate	Yes	G4	S1	Critical/declining
White-belted Ringtail (*Erpetogomphus compositus*)	None	Candidate	No	G5	S1	Low/unknown
	Climate vulnerability: Moderate-high					

Biology and Life History

White-belted Ringtail
Photo: W. Leonard

Clubtail dragonflies complete a life cycle composed of two main phases: a flightless aquatic larva (nymph stage), which may be continuous for one to two winters, and the adult flight (reproductive stage). They inhabit sites year-round as egg, larval nymph, and adult, typically moving within only a few to several hundred meters of their natal locations. Adults do not seasonally migrate, and die soon after their reproductive summer. Both life stages are predatory; the majority of life cycle is spent as aquatic larvae. Nymphs feed on aquatic invertebrates and possibly small vertebrates (fish, frog and salamander larva). After multiple aquatic instars (gradual metamorphosis) over one or two winters, mature nymphs crawl onto rocks or vegetation and shed their exoskeleton to become a new adult (teneral) in late spring and summer. Adults are aerial predators of smaller insects and similar sized butterflies and moths (Lepidoptera), as well as smaller Odonates. Water temperature influences the timing of emergence from within a year or over two years. Weather influences flight period duration, with wet or cold conditions potentially shortening the flight period and warm, dry conditions promoting the duration and later occurrence dates of the flight period. Male Clubtails seek mates by patrolling a territory that coincides with optimal aquatic habitat for female egg-laying, and hence for larvae. There is usually no courtship behavior. After copulation, females usually hover just above the water of slow moving or gentle current stretches and close to shore while periodically dipping the tail to deposit multiple eggs.

Distribution and Abundance

These species occur in low numbers of small isolated populations (Table 1). For the Columbia Clubtail, only a single population is known in Washington. Only three localities in Washington are known for the Pacific Clubtail, and confirmation is needed for the Thurston County location; a historical record exists from Lake Washington (King County, 1933). The White-belted Ringtail is more widespread throughout the western U.S., but restricted to two known locales in Washington, the extreme northern end of its range.

Table 1. Overall range, counties and estimated number of extant populations in Washington for Dragonfly SGCN.

Species	Range Overall	WA Counties	Populations
Columbia Clubtail	Highly disjunct: E WA; John Day, Owyhee, Malheur rivers in OR	Benton - Yakima River Horn, north of Benton City (1000')	1
Pacific Clubtail	Restricted to N CA–OR Pacific coast and mountains - north to S Puget Trough	Skamania - Bass, Ice House Lakes; Thurston - Black Lake	3?
White-belted Ringtail	Local in S part of Columbia Basin (1000'); CA, ID, OR, NV, AZ, NM, UT, TX	Grant - Crab Creek Benton - Yakima River.	2

Habitat

Research is needed to quantify specific habitat requirements for these species, including aquatic larval substrates, river and stream, or lake and pond characteristics, and other key habitat features.

Columbia Clubtail: Over its range, uses slower-moving, open sandy to muddy, rivers with gravelly rapids in sagebrush-riparian woodland; may be more widespread in Washington.

Pacific Clubtail: At large ponds and lakes in western Washington; in other parts of range, streams and rivers with good currents, sandy to muddy bottoms.

White-belted Ringtail: Open sandy streams/rivers, irrigation ditches, occasionally sink holes; typically in desert country, sagebrush-riparian woodland.

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Family Gomphidae: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
1	Agriculture and aquaculture side effects	Pesticide and fertilizer runoff into streams	Monitor occurrence waters for chemical contaminants	Nothing current - new action needed	Both
2	Agriculture and aquaculture side effects	Siltation and degradation of stream and bottom habitat used by developing larvae by unsustainable grazing, commercial or recreational uses	Work to improve unsustainable grazing and commercial use practices in waters of known occurrence	Nothing current - new action needed	Both
3	Climate change and severe weather	Increased environmental temperatures may affect life history with unknown consequences	Monitor streams in context of climate changes	Nothing current - new action needed	Both
4	Fish and wildlife habitat loss or degradation	Vulnerable mostly because of extreme rarity of any known populations	Efforts that protect water quality most important to larval development. Use land acquisitions, conservation easements and landowner agreements to protect significant shoreline areas from degradation	Nothing current - new action needed	Both
5	Fish and wildlife habitat loss or degradation	Loss of riparian vegetation that provide shade and perch sites; ameliorates stream temps.	Monitor vegetation around know occurrence sites	Nothing current - new action needed	Both
6	Invasive and other problematic species	Introduced predatory fish species that may not have co-evolved with these species	Monitor streams in context of non-native aquatic species	Nothing current - new action needed	Both

NOTE: Numbers are for reference only and do not reflect priority.

SUBARCTIC BLUET (*Coenagrion interrogatum*)

Conservation Status and Concern

The Subarctic Bluet is a species of damselfly that is restricted to boreal fens and bogs in the northeastern corner of the state. Only two populations of Subarctic Bluet have been located in Washington.

Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend	Climate Vulnerability
None	None	No	G5	S1	Low/unknown	Moderate-high

Biology and Life History

The Subarctic Bluet is a damselfly in the pond damsel family (Coenagrionidae). Adults mate in dense vegetation; females lay eggs in small slits they cut in aquatic plants and have been observed egg-laying in floating sedge and grass leaves and stems, and emergent grass stems. Eggs develop quickly, and the resulting larvae are aquatic and feed on other aquatic invertebrates. This species overwinters in the larval stage. Adults are also predators that specialize on flying insects. The adult period for this species may be relatively short; adults have been detected at Washington sites in July.

Photo: M. Reese

Distribution and Abundance

The Subarctic Bluet is a boreal species, and ranges across most of Canada and into the western United States in northern Washington and Montana. The species is known from only two sites in Washington, in Ferry and Pend Oreille Counties, between 4500 to 5000 feet in elevation. It may occur in additional boreal bogs and fens in this region. There is no information on population size from either Washington locality.

Habitat

This species depends on boreal bogs and fens, rare habitat types that are restricted to the northeast corner of the state. Within these rare wetlands, Subarctic Bluets use dense sedge and moss mats, and adults also use the shrub ecotone. These habitats are sensitive to disturbance and many activities that impact local hydrology.

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Subarctic Bluet: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
1	Agriculture and aquaculture side effects	Bog/fen obligate; habitat and species are vulnerable to alteration of local hydrology from logging and road building	Identify bog/fen sites and landowners within species range and develop plans to conserve	Nothing current - new action needed	Both
2	Resource information collection needs	Lack of data on current status and distribution	Determine distribution, population status	Current insufficient	Both

NOTE: Numbers are for reference only and do not reflect priority.

STONEFLIES (Plecoptera)

Conservation Status and Concern

Stoneflies generally require cold, clear, running water and are especially sensitive to human disturbance; they are excellent indicators of water quality. An estimated 43 percent of North American stoneflies are vulnerable to extinction, imperiled, or extinct. Adults are weak fliers, and there is a high level of endemism; four of these species have only been found in Washington. Some of these species are restricted to glacier-fed streams, at risk due to climate change.

Common Name (Scientific name)	Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend
Sasquatch Snowfly (*Bolshecapnia sasquatchi*)	None	None	No	G2	SNR	Low/unknown
Northern Forestfly (*Lednia borealis*)	Candidate	None	No	G3G4	S3S4	Low/unknown
Wenatchee Forestfly (*Malenka wenatchee*)	None	None	No	G2	SU	Low/unknown
Pacific Needlefly *(Megaleuctra complicata)*	None	None	No	G3	SU	Low/unknown
Cascades Needlefly *(Megaleuctra kincaidi)*	None	None	No	G2	SU	Low/unknown
Yosemite Springfly *(Megarcys yosemite)*	None	None	No	G2	SNR	Low/unknown
Talol Springfly *(Pictetiella lechleitneri)*	None	None	No	G1G3	SNR	Low/unknown
Rainier Roachfly *(Soliperla fenderi)*	None	None	No	G2	S1S2	Low/unknown

CLIMATE VULNERABILITY RANKING	
Common Name (Scientific name)	Ranking
Sasquatch Snowfly (*Bolshecapnia sasquatchi*)	Moderate-high
Northern Forestfly (*Lednia borealis*)	High
Wenatchee Forestfly (*Malenka wenatchee*)	Moderate-high
Pacific Needlefly *(Megaleuctra complicata)*	Moderate-high
Cascades Needlefly *(Megaleuctra kincaidi)*	Moderate-high
Yosemite Springfly *(Megarcys yosemite)*	High
Talol Springfly *(Pictetiella lechleitneri)*	Moderate
Rainier Roachfly *(Soliperla fenderi)*	Moderate-high

Taxonomic note: The Northern Forestfly (*Lednia borealis*) was recently described from specimens originally identified as *L. tumana*, a Candidate for listing under the Endangered Species Act (ESA). The Talol Springfly (*Pictetiella lechleitneri*) was described by Stark and Kondratieff (2004). Baumann and Potter (2007) determined that *Bolshecapnia sasquatchi* is restricted to British Columbia and Washington; Montana specimens, previously assigned to this species, were described as *B. missiona.* *Soliperla* specimens from Mt. Adams, Skamania County, were originally thought to be *S. fenderi*, but have been reclassified as the type specimens of a new species, *S. cowlitz*.

Biology and Life History


Soliperla sierra, a close relative of *S. fenderi*
Photo: B. Stark

Stoneflies usually live in areas with running water, and are important predators and shredders in aquatic ecosystems. The females lay hundreds or even thousands of eggs in a ball which they initially carry on their abdomens, and later deposit into the water. The eggs typically hatch in two to three weeks, but some species undergo diapause as eggs during the dry season. The nymphs physically resemble wingless adults, but often have external gills, which may be present on almost any part of the body. The nymphs (technically, "naiads") are aquatic and live in the benthic zone of well-oxygenated creeks and lakes. In early stages (called instars), stoneflies tend to be herbivores or detritivores, feeding on plant material such as algae, leaves, and other fresh or decaying vegetation; in later instars, the nymphs of many species shift to being omnivores or carnivores, and some species become predators on other aquatic invertebrates. The insects remain in the nymphal form for one to four years, depending on species, and undergo from 12 to 33 molts before emerging and becoming terrestrial as adults. Stonefly adults are generally weak fliers and stay close to stream, river, or lake margins where the nymphs are likely to be found. The adults emerge only during specific times of the year and only survive one to four weeks. As adults, very few stonefly species feed but those that do, feed on algae and lichens, nectar, or pollen.

Distribution and Abundance

Sasquatch Snowfly: This species' range includes Washington and British Columbia. In Washington, it is known from Lewis and Whatcom Counties (Ohanapecosh River, Mt. Rainier

National Park, and Razor Hone Creek, near Mt. Baker). British Columbia records are from the Fraser River near Agassiz, and the Similkameen and Skagit rivers in Manning Provincial Park.

Northern Forestfly: The Northern Forestfly, a Washington endemic, is only known from high elevation glacial-fed streams in the Cascades, including Mt. Rainier and North Cascades National Parks, and Mt. Baker-Snoqualmie National Forest.

Wenatchee Forestfly: This species is known only from springs draining into Lake Wenatchee in Chelan County, Washington.

Pacific Needlefly: Megaleuctra species are "always rare". This species is found in the Cascades in Washington, Oregon, and northern California. Washington records include King, Pierce, Lewis, Skamania, and Cowlitz Counties.

Cascades Needlefly: This species is known from a few dozen occurrences from Oregon and Washington. An additional record is available from Lolo Pass, Clearwater County, Idaho and the Flathead River basin in western Montana.

Yosemite Springfly: It is known from Mt Rainier National Park (Fryingpan Creek at Sunrise Road Bridge, Pierce County), Mt. Hood, Oregon, and Mt. Lyell, (Yosemite National Park) California.

Talol Springfly: This species is only known from Carbon River, Mt. Rainier National Park, Pierce County, Washington.

Rainier Roachfly: This species is known from around fifteen occurrences within Mt. Rainier National Park, Pierce County, Washington. The species is presently known only from the Mt. Rainier National Park, but may occur elsewhere.

Habitat

Adults are terrestrial and can be found near aquatic habitats with running water, resting on rocks, debris, and vegetation. As nymphs, stoneflies live in aquatic habitats, mainly along the bottom of cool, clean, flowing waters with relatively high oxygen concentrations, mainly on rocky, stony, or gravel substrates. A few species are found in cold ponds and lakes at high elevations and northern latitudes.

Sasquatch Snowfly: This species is associated with creeks and rivers.

Northern Forestfly: This species has been collected from springs draining into alpine lakes.

Needleflies: These species are restricted to springs, seeps and rheocrenes (springs that flow from a defined opening into a confined channel). *Megaleuctra* species are usually associated with spring seeps and rheocrenes. They inhabit exclusively spring habitats, ranging from small seeps to large flowing springs. Even when it occurs in large springs, it is usually found along the edges instead of out in the area of flow. Water quality must be consistently good and the temperature cold. The nymphs are often found in small, consistently wet seepage areas some distance from nearest the creek, river or lake habitat. The essential habitat for the nymphs is springs or seeps that might not even be visibly flowing.

Wenatchee Forestfly: The Wenatchee Forestfly is found in springs draining into a large lake.

Yosemite Springfly: This species is reported from glacier-fed streams.

Talol Springfly: This species is reported from glacier-fed streams.

Rainier Roachfly: This species occurs in spring-fed seeps and streams (rheocrenes). Nymphs in this genus are generally collected in seeps and in the splash zones of small springs and streams.

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Stoneflies: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
Cascades Needlefly, Northern Forestfly, Pacific Needlefly, Rainier Roachfly, Wenatchee Forestfly					
1	Resource information collection needs	Lack of data on current status and distribution	Determine distribution, population status	Current insufficient	Both
2	Climate change and severe weather	Potential for springs to dry up	Monitor spring/seep habitats	Current insufficient	Both
Sasquatch Snowfly					
1	Resource information collection needs	Lack of data on current status and distribution	Determine distribution, population status	Current insufficient	Both
Talol Springfly					
1	Resource information collection needs	Lack of data on current status and distribution	Determine distribution, population status	Current insufficient	Both
2	Resource information collection needs	Little life history information	Investigate life history, ecology	Nothing current - new action needed	External
3	Climate change and severe weather	Potential for glacial-fed habitat to dry up	Monitor glacial-fed river habitat	Current insufficient	External
Yosemite Springfly					
1	Resource Information Collection Needs	Lack of data on current status and distribution	Determine distribution, population status	Current insufficient	Both

NOTE: Numbers are for reference only and do not reflect priority.

BEETLES

HATCH'S CLICK BEETLE (*Eanus hatchi*)

Conservation Status and Concern
Hatch's Click Beetle is a SGCN due to its small number of isolated populations, highly limited distribution and range, and use of specialized, highly restricted, and threatened *Sphagnum* moss bog habitat.

Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend	Climate Vulnerability
None	Candidate	Yes	G1	S1	Low/declining	Moderate-high

Biology and Life History
Click beetles (Elateridae) have a unique prothorax anatomy that allows them to suddenly flip into the air, emitting a 'click' sound. This behavior is used to right the beetle when on its back and to escape predators. Adult Hatch's Click Beetles are active in the spring, typically on floating mats of Sphagnum moss. Elaterid adults and larvae are known to be carnivorous as well as herbivorous; however, no studies of adult or larval *E. hatchi* diets have been reported. Adults are thought to feed within flowers on honey dew, pollen, nectar, and the flowers themselves. Larvae appear to inhabit *Sphagnum* moss mats, and likely predate small insects and require multiple years to develop.

Photo: T. Loh

Distribution and Abundance
Known from only four bogs in lowland King and Snohomish Counties; one of these sites is now highly degraded and unlikely to support this beetle. Extensive searches have been made for Hatch's Click Beetle; however, additional surveys in the Puget Trough region are needed. No populations of this species have been estimated.

Habitat
Hatch's Click Beetle is a *Sphagnum* bog obligate species, inhabiting bogs between 0 to 1640 feet in elevation. *Sphagnum* bogs are unique, peat-forming wetlands with vegetation dominated by *Sphagnum* mosses. Bogs are typically small in size and situated in closed depressions within small watersheds, and thus geographically isolated. An ancient habitat, today bogs persist in relict patches that thousands of years ago were part of more broadly occurring muskeg-like vegetation following the retreat of the glaciers at the end of the last ice age. *Sphagnum* bogs make up only three percent of the wetlands in western Washington. Adults have been collected in low, floating *Sphagnum* mats and also encountered in bog shrubs and trees. Larvae have been found near bog margins, above the water line. No formal habitat studies have been conducted for this rare beetle.

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Hatch's Click Beetle: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
1	Fish and wildlife habitat loss or degradation	Bog/fen obligate; habitat and species are vulnerable to alteration of local hydrology from development	Designation of sites as having unique and important value to fish and wildlife	Current insufficient	Both

NOTE: Numbers are for reference only and do not reflect priority.

Family Carabidae: GROUND AND TIGER BEETLES

Conservation Status and Concern

These four beetle species are SGCN due to the small number of isolated populations, highly limited distribution and range, and dependence on specialized, restricted and threatened habitats.

Common Name (Scientific name)	Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend
Mann's Mollusk-eating Ground Beetle (*Scaphinotus mannii*)	None	Candidate	Yes	GNR	SNR	Low/unknown
Beller's Ground Beetle (*Agonum belleri*)	None	Candidate	Yes	G3	S3	Low/unknown
Columbia River Tiger Beetle (*Cicindela columbica*)	None	Candidate	Yes	G2	SH	Extirpated?
Siuslaw Sand Tiger Beetle (*Cicindela hirticollis siuslawensis*)	None	Monitor	No	G5T1T2	S1	Critical/unknown

CLIMATE VULNERABILITY RANKING	
Common Name (Scientific name)	Ranking
Mann's Mollusk-eating Ground Beetle *(Scaphinotus mannii)*	Moderate-high
Beller's Ground Beetle *(Agonum belleri)*	Moderate-high
Columbia River Tiger Beetle *(Cicindela columbica)*	Moderate
Siuslaw Sand Tiger Beetle *(Cicindela hirticollis siuslawensis)*	Moderate-high

Biology and Life History


Siuslaw Sand Tiger Beetle
Photo: R. Lyons, Xerxes Society

Four Carabidae beetles are designated as SGCN in Washington; two are ground beetles (subfamily Carabinae) and two are tiger beetles (subfamily Cicindelinae). Carabid beetles live on and in the soil; carabid SGCN depend on a narrow range of soil conditions within rare habitat types. Carabids are key predators of the insect world; as both larvae and adults they feed on other insects and, to a lesser extent, plant material. Adults hunt by sight and are fast runners that can quickly subdue their prey. Siuslaw Sand Tiger Beetle, Columbia River Tiger Beetle, and Beller's Ground Beetle adults generally forage during the day, and at night burrow into soil, sand, or other substrate. Mann's Mollusk-eating Ground Beetle is a slug and snail feeding specialist; adults hunt at night, taking cover under stones during the day. Carabids undergo complete metamorphosis, which means they have egg, larval, pupal, and adult life stages. Females create shallow burrows in the soil with their ovipositor, where they lay eggs singly; larvae feed and develop, pupation occurs, and adults emerge from these tunnel-like burrows. Thus, soil condition, including texture, moisture, and temperature is a vital element of habitat quality. Carabid beetles typically reproduce annually; adults can live for several years, and larvae may require multiple years for complete development. Mann's Mollusk-eating Ground Beetle and Beller's Ground Beetle are flightless species with highly limited dispersal capability. Adults of both tiger beetle SGCN can fly, but these species too are highly localized and sedentary. All four carabid SGCN inhabit their sites year-round (as egg, larva, pupa and adult).

Distribution and Abundance

Carabid beetle SGCN have restricted ranges and distributions within Washington (summarized in Table 1). Distribution is limited in part by a combination of their dependence on restricted ecological niches, and those niches' location within rare habitat types. Their distribution and abundance is characterized by small numbers of isolated populations. Limited surveys have been conducted in Washington to determine the current distribution of Mann's Mollusk-eating Ground Beetle, Beller's Ground Beetle, and Columbia River Tiger Beetle. However, further surveys are needed to determine their distributions, and locate any extant Washington populations of Columbia River Tiger Beetle and Siuslaw Sand Tiger Beetle. Population sizes have not been determined for these species on any site.

Overall range, WA counties and estimated number of extant populations for carabid beetle SGCN.

Species	Range Overall	Washington Counties	Populations
Mann's Mollusk-eating Ground Beetle	SE WA and NE Oregon: Snake River tributaries	Asotin, Whitman	<10
Beller's Ground Beetle	Disjunct: Queen Charlotte Islands, SW British Columbia (Canada); Puget Sound lowlands, WA; NW Oregon	King, Kitsap, Mason, Skagit, Snohomish, Thurston	20-30
Columbia River Tiger Beetle	SE WA, NE Oregon, Idaho: along the Columbia, Snake, and Salmon Rivers Recent detection: Idaho only	Asotin, Benton, Columbia, Franklin, Garfield, Walla Walla	Extant?
Siuslaw Sand Tiger Beetle	Coastal beaches SW WA south to N California. Recent detections: Oregon only	Pacific	Extant?

Habitat

Carabid beetles occupy a wide variety of habitat types and ecological niches. The four Washington carabid SGCN are habitat specialists; they require soil and substrate texture, temperature, and moisture within narrow ranges, and those conditions must be found within rare habitat types, for example *Sphagnum* bogs or undisturbed and uniquely situated riverine or coastal sands.

Mann's Mollusk-eating Ground Beetle: This species uses shaded moist ground in low elevation (less than 2600 feet) forest and shrub-vegetated springs and damp canyons within the Snake River drainage that are not subject to periodic inundation of water from dams.

Beller's Ground Beetle: This species occurs only in low to mid-elevation (less than 3280 feet) Puget Trough *Sphagnum* bogs; unique, peat-forming wetlands with vegetation dominated by

Sphagnum genus mosses. *Sphagnum* bogs are typically small in size and situated in closed depressions within small watersheds, and thus are geographically isolated. An ancient habitat, today bogs persist in relict patches that thousands of years ago were part of more broadly occurring muskeg-like vegetation. *Sphagnum* bogs make up only three percent of the wetlands in western Washington.

Columbia River Tiger Beetle: This beetle uses well-established riverine sandbars and dunes along the Columbia and Snake River systems that are not inundated by spring floods or high water levels resulting from dam management. These sand habitats are open and only sparsely vegetated with shrubs and herbaceous species.

Siuslaw Sand Tiger Beetle: Inhabits a narrow ecological niche: unvegetated sands at the edge of freshwater outflows on Pacific Coast beaches. A study of this species' habitat in Oregon found adult beetles using firm, flat, moist sand at and near the freshwater edge, including areas upstream of the river mouth and along backwater lagoons and wetlands; and the sloping edge of dryer dunes just above the river's high water mark.

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Family Carabidae: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
Columbia River Tiger Beetle					
1	Energy development and distribution	Requires narrow range of soil texture and moisture: threatened by inundation of reservoirs on Columbia/Snake Rivers	Where dams remain in rivers, develop timing and duration water level control best management practices to support species	Nothing current - new action needed	Both
2	Resource information collection needs	Knowledge of current distribution is incomplete	Conduct baseline inventory on Snake River, and revisit historic locales and potential habitat on Columbia	Nothing current - new action needed	Resource Information Collection Needs
Mann's Mollusk-eating Ground Beetle					
1	Energy development and distribution	Requires riparian forest areas threatened by inundation of reservoirs on Snake River	Where dams remain in rivers, develop timing and duration water level control best management practices to support species	Nothing current - new action needed	Both
2	Agriculture and aquaculture side effects	Intensive livestock use may trample the beetle or reduce riparian vegetation and compact soil	Install fencing to carefully manage or prohibit livestock access to occupied riparian areas	Nothing current - new action needed	Both
3	Resource information collection needs	Lacking information on complete species distribution in WA, ID, and OR	Conduct baseline inventory along Snake River	Nothing current - new action needed	Both
Beller's Ground Beetle					
1	Fish and wildlife habitat loss or degradation	Bog/fen obligate; habitat and species are vulnerable to alteration of local hydrology from development	Designation of sites as having unique and important value to fish and wildlife	Current insufficient	Both
2	Agriculture and aquaculture side effects	Bog/fen obligate; habitat and species are vulnerable to alteration of local hydrology from logging and road building	Leading or participating in land use planning for rural, urban, and forestry lands	Current insufficient	Both
3	Resource information collection needs	Knowledge of current distribution is incomplete	Baseline survey and inventory to understand distribution of fish and wildlife populations	Current insufficient	Both

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
Siuslaw Sand Tiger Beetle					
1	Invasive and other problematic species	Invasive plants, those currently here, and many yet to come in the future, establish in habitat and stabilize soil, thereby making habitat unsuitable	Using herbicide and mechanical methods to maintain open ground and appropriate soil condition	Nothing current - new action needed	Both
2	Resource Information Collection Needs	Need to determine where extant in WA	Revisit historic locales and search for new populations	Current insufficient	Both

NOTE: Numbers are for reference only and do not reflect priority.

CADDISFLIES

CADDISFLIES (Trichoptera)

Conservation Status and Concern

Caddisflies are aquatic insects. They are very sensitive to water quality and changes in water flow. Certain species have been used as biotic indicators of pollution.

Common Name (Scientific name)	Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend
[unnamed] (*Allomyia acanthis*)	None	None	No	G2G3	SNR	Low/unknown
[unnamed] (*Goereilla baumanni*)	None	None	No	G2	SNR	Low/unknown
[unnamed] *(Limnephilus flavastellus)*	None	None	No	G2	SNR	Low/unknown
[unnamed] *(Psychoglypha browni)*	None	None	No	G2G4	SNR	Low/unknown
[unnamed] *(Rhyacophila pichaca)*	None	None	No	G2G3	SNR	Low/unknown
[unnamed] *(Rhyacophila vetina)*	None	None	No	G2	SNR	Low/unknown

CLIMATE VULNERABILITY RANKING	
Common Name (Scientific name)	Ranking
[unnamed] (*Allomyia acanthis)*	High
[unnamed] *(Goereilla baumanni)*	High
[unnamed] (*Limnephilus flavastellus)*	Moderate-high
[unnamed] (*Psychoglypha browni)*	Moderate-high
[unnamed] (*Rhyacophila pichaca)*	Moderate
[unnamed] (*Rhyacophila vetina)*	High

Biology and Life History

Caddisflies are closely related to the Lepidoptera (moths and butterflies). They are aquatic in the immature stages. During the day, adults hide in cool, moist environments such as the vegetation along river banks. Few species have actually been observed feeding; they imbibe nectar. The body and wings are covered with long silky hairs (setae) – a distinctive characteristic of the order. Adults live several weeks and usually mate on vegetation or rocks surrounding water. There is generally one complete generation per year, although some species require two years for development and some less than a year. Eggs, in masses numbering up to 800, are laid within a jelly that swells on contact with water. A female may wash off a partially extruded egg mass by dipping her abdomen into water during flight, or she may place the mass on stones in the water or on aquatic plants just above the water. Young larvae hatch within a few days and most species progress through five instars before emerging as a winged adult. Although most larvae feed on aquatic plants, algae, diatoms, or plant debris, a few are predatory on other aquatic insects, crustaceans, and mollusks, and a few are omnivorous. The larvae play an important role in the aquatic community, reducing plant growth and disposing of animal and plant debris. In some species the larvae form webs of debris for protection, while others form a funnel-like web between stones in running water to catch food. Some protect their bodies with cases, whereas others spin protective lairs or are free-living. They produce silk from glands on the lower lip (labium), and many herbivorous species spin tubular protective cases that are open at both ends and enlarge as the larvae grow. Sand grains, pebbles, bits of wood or vegetation are added to cases to provide protection and rigidity. In case-bearing forms, the head and thorax protrude from the case, which is pulled along by the abdomen. The larva pupates inside the larval case, which then becomes a cocoon, or inside a specially constructed cocoon. After two or three weeks the pupa bites its way out of the cocoon and swims or crawls to the water surface, using its hair-fringed middle pair of legs. Caddisfly adults sometimes emerge in large numbers, often forming swarms. Adults tend to remain somewhat near the emergence site where oviposition occurs. They tend to disperse shorter distances in dense forest compared with more open vegetation. Although dispersal flights are common, such flights are relatively short and only occur immediately following emergence. Large river caddisflies have been collected over three miles from water.

Rhyacophila acutiloba – a caddisfly in the Rhyacophila genus.
Photo: T. Murray

Distribution and Abundance

***Allomyia acanthis*:** Adults of this species are known from the Cascade Range in Washington and Oregon. Reported from Paradise Ice Caves, Mt. Rainier National Park, Pierce County, Washington. Larvae are undescribed/unknown. *Allomyia* species occur in very small, localized populations, with many isolated mountains inhabited by a single endemic species, and many species in this genus remain undescribed or undiscovered.

***Goereilla baumanni*:** In Washington, this species is known from streams in the Big Spring Picnic Ground on Mt. Spokane, Spokane County. Also reported from spring seepage areas in Montana and Idaho. In all three states, it is always reported in very low abundance.

***Limnephilus flavastellus*:** This species has been recorded in Mason County, and was recently reported from Mt. Rainier National Park, Pierce County, Washington. It is also found in British Columbia, Oregon (Douglas, Klamath, Yamhill Counties). The larvae are undescribed/unknown.

***Psychoglypha browni*:** Recently reported from Mt. Rainier National Park, Pierce County, Washington. Adults are known from Oregon (Clackamas, Klamath, and Lane Counties). The larvae are undescribed/unknown.

***Rhyacophila pichaca*:** This species is recorded from Olympic Hot Springs, Boulder Lake, Washington, Clallam County. Also known from Cascade Head Experimental Forest, Tillamook County, near Otis, Oregon.

***Rhyacophila vetina*:** This species is uncommon in the high Cascades of Washington. It was recently reported from Mt. Rainier National Park, Lewis and Pierce Counties. It has also been reported in Clackamas County, Oregon.

Habitat

Most North American caddisfly species occur in cool, running freshwater, but some also occur in most types of freshwater habitats: spring streams and seepage areas, rivers, lakes, marshes, and temporary pools.

***A. acanthis*:** This species is normally found in very cold, high altitude springs, seeps, and small spring streams up to six feet across. They are often found grazing on the surface or sides of larger rocks in open, sunny areas.

***G. baumanni*:** *G. baumanni* appears to inhabit organic muck in spring areas. It is currently known from higher altitudes.

***L. flavastellus*:** This species has a broad altitudinal range from low altitude valley ponds to high mountain ponds and lakes, and is tolerant of large temperature variations. It is most abundant in waters without salmonids.

***P. browni*:** This species inhabits depositional areas of streams and large springs in mid- and high altitude localities.

***R. pichaca*:** This species has been found at low and high altitude lakes, possibly along tributaries. Specific habitat information has not been described.

***R. vetina*:** This species is associated with cold springs and spring channels at mid- to high altitudes.

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Caddisflies: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
1	Resource information collection needs	Lack of data on current status and distribution	Determine distribution, population status	Current insufficient	Both
2	Climate change and severe weather	Drying of streams	Determine distribution, population status	Current insufficient	Both
3	Fish and wildlife habitat loss or degradation	Water quality is of extreme importance to aquatic insects.	Protect riparian habitats	Current insufficient	Both

NOTE: Numbers are for reference only and do not reflect priority.

MOTHS

Genus *Copablepharon*

Conservation Status and Concern

These four *Copablepharon* moths (Family Noctuidae) are imperiled due to rare habitat types, small number of isolated populations, extremely limited range, and known threats to their habitats. The Sand Verbena Moth was petitioned for listing under the ESA, and the US Fish and Wildlife Service (USFWS) found “the petition presents substantial information indicating that listing the Sand Verbena Moth may be warranted.”

Common Name (Scientific name)	Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend
Sand Verbena Moth (*Copablepharon fuscum*)	In review	Candidate	Yes	G1G2	S1	Low/unknown
[unnamed] *(Copablepharon columbia)*	None	None	No	GNR	SNR	Critical/declining
[unnamed] *(Copablepharon mutans)*	None	None	No	GNR	SNR	Critical/declining
[unnamed] *(Copablepharon viridisparsa hopfingeri)*	None	None	No	GNR	SNR	Critical/declining

CLIMATE VULNERABILITY RANKING	
Common Name (Scientific name)	Ranking
Sand Verbena Moth *(Copablepharon fuscum)*	Moderate-high
[unnamed] *(Copablepharon columbia)*	Moderate
[unnamed] (*Copablepharon mutans)*	Moderate
[unnamed] *(Copablepharon viridisparsa hopfingeri)*	Moderate

Biology and Life History

Sand Verbena Moth larva feeding on host flowers. Photo: N. Page

The Sand Verbena Moth was discovered on a few coastal beach sites on Vancouver Island, British Columbia, Canada, and Whidbey Island, in northwestern Washington, and described as a new species in 1995. The three additional *Copablepharon* moth species were described in 2004. They inhabit small, geographically isolated sand dune complexes in the Columbia River Basin of eastern Washington, rare ecological systems that are threatened by several factors. There has been little study of the biology and life history of these species. Sand Verbena Moth has received some attention from Pacific Northwest biologists; however, even host plants are not confirmed for the other three species. *Copablepharon* moths complete a single life cycle annually (univoltine). They are sedentary, nocturnal moths that do not stray far from their restricted habitats and host plants. Specialists of well-drained and sandy soils, the larvae burrow into the soil, emerging at night to feed on vegetation. Sand Verbena Moth larvae feed on only a single plant, yellow sand verbena (*Abronia latifolia*) (Family Nyctaginaceae), a regionally rare, perennial species found on coastal dunes and beaches. Adult moths nectar primarily from this plant as well and females lay eggs directly on the flowers. Larvae feed on both flowers and leaves. Adults are present from mid-May through early July, and usually fly during dusk and early evening. Larvae are dormant, burrowed in the sand during winter, reemerging in early-spring to feed and then pupate. *C. columbia* adults occur in early-June; *C. mutans* adults in late August and early September; and *C. viridisparsa hopfingeri* flies in July and August.

Distribution and Abundance

The distributions of these species are limited by their dependence on rare and highly restricted ecological systems. An endemic of Salish Sea sandy coastal sites, the Sand Verbena Moth is known from only 10 sites; five on Vancouver Island, British Columbia, Canada, and five in Washington along the eastern edge of the Straits of Juan de Fuca (San Juan, Island, Jefferson, and Clallam Counties). Sand Verbena Moth is the only *Copablepharon* species known from west of the Cascades Mountains. Recent efforts have been made to locate additional populations within and outside of this area.

C. columbia, C. mutans, and C. viridisparsa hopfingeri are each restricted to a small number of sand dune sites in the semiarid Columbia Basin in eastern Washington. *C. columbia* is known from only a single sand dune complex, located on the southwest shore of Moses Lake (Grant County), and despite extensive sampling in this region, most specimens have been collected from a single dune within this site. *C. mutans* has been found in two sand dune areas along the Columbia River: near the Wanapum Dam (Grant County) and within the US Department of Energy Hanford site (Benton County). *C. viridisparsa hopfingeri* historically occurred in sand dunes along the Columbia River from Trail, British Columbia, Canada to Wenatchee, Washington. However, the only recent records are from Bridgeport State Park (Okanogan County) and Fort Spokane State Park (Lincoln County).

Habitat

Copablepharon moths are habitat specialists that rely on loose, well-drained soils, especially sand. They are restricted to active (non-stabilized) sandy sites, coastal sand beaches and spits for Sand Verbena Moth, and for the three other taxa, inland sand dunes in an arid shrub-steppe setting. The sands in all cases are glacially derived, and wind action provides soil disturbance that supports native vegetation. Beach and sand dune sites that have been stabilized from introduced plants or by other actions typically lose much of their native vegetation. These sand substrate habitats are rare in the Pacific Northwest. Additional habitat parameters are known for Sand Verbena Moth, which has received some study; this moth persists only on sites with large, dense, flowering patches of yellow sand verbena.

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Genus Copablepharon: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
Sand Verbena Moth					
1	Climate change and severe weather	Populations located adjacent to marine waters- that are rising	Evaluate landscape and develop plan to increase habitat area and habitat heterogeneity in currently occupied sites and within occupied landscapes	Nothing current - new action needed	Both
2	Invasive and other problematic species	Invasive plants, those currently here, and many yet to come in the future, out-compete natives and otherwise make habitat unsuitable	Using herbicide and mechanical methods to maintain open sand dunes	Nothing current - new action needed	Both
Copablepharon columbia					
1	Invasive and other problematic species	Sand dune obligate: dunes are being stabilized by invasive species, especially cheatgrass	Eradicate cheatgrass and other invasive plants from dune systems	Nothing current - new action needed	Both
Copablepharon mutans					
1	Invasive and other problematic species	Sand dune obligate: dunes are being stabilized by invasive species, especially cheatgrass	Eradicate cheatgrass and other invasive plants from dune systems	Nothing current - new action needed	Both
Copablepharon viridisparsa hopfingeri					
1	Invasive and other problematic species	Sand dune obligate: dunes are being stabilized by invasive species, especially cheatgrass	Eradicate cheatgrass and other invasive plants from dune systems	Nothing current - new action needed	Both

NOTE: Numbers are for reference only and do not reflect priority.

BUTTERFLIES

GREAT ARCTIC *(Oeneis nevadensis gigas)*

Conservation Status and Concern
A Pacific Northwest endemic, this butterfly has been found on a single site within the United States, in northwestern Washington; it also occurs in southwestern British Columbia, and may occur on other sites with similar habitat. It is a SGCN due to its restricted range, distribution, and habitat, and many threats to its grassland-forest edge habitat.

Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend	Climate Vulnerability
None	Candidate	Yes	G5TU	SH	Critical/unknown	Low-moderate

Biology and Life History
The Great Arctic, a member of the Satyr (Satyrinae) butterfly subfamily, is a large tawny brown butterfly with a bark-like patterned ventral hindwing, such that when perched they are quite camouflaged. Great Arctic belongs to a group of butterflies, the arctics and alpines, that inhabit far northern and alpine climes. One unusual aspect of their life history is a life cycle, from egg to adult that spans two years. The life history of Great Artic is not well known. Adults are present in June and July, and females lay eggs on unknown species of grasses where larvae develop over two years; the timing and location of larval and pupal stages are unknown. This two-year life cycle is synchronized amongst individuals and results in adults mostly occurring in even-numbered years. Males exhibit territorial flight behaviors of perching and patrolling, and are known to congregate on ridges and hilltops, a behavior called "hilltopping". This butterfly's habits of jerky flights through open forest and perching on trees where they are concealed makes them difficult to detect.


Photo: M. Patterson

Distribution and Abundance
The species occurs in British Columbia, primarily on Vancouver Island, with a few sites in the mainland Coast Range, and a single site known from Washington, on Orcas Island (San Juan County) in the northwestern portion of the state. Recent efforts to relocate Great Arctic on Orcas Island have been inconclusive; WDFW surveyors had fleeting observations of unidentified but similar looking butterflies, and located additional potential habitat for future survey. If this butterfly persists in Washington, population sizes are likely small.

Habitat
The Great Arctic inhabits forest openings, meadow edges, and rocky slopes and outcrops from sea level to mid-elevations. Aside from dependence on specific but unknown grasses and forest edge ecotone, little is known of their habitat requirements.

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Great Arctic: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
1	Resource information collection Needs	Current status and distribution in WA unknown	Survey historic locale and other potential sites	Current insufficient	WDFW
2	Invasive and other problematic species	Forest encroachment due to long-term fire suppression has reduced amount and quality of habitat. Host plant is a grass, and species utilizes open forest and forest edge	Remove invading trees and shrubs	Nothing current - new action needed	Both

NOTE: Numbers are for reference only and do not reflect priority.

ISLAND MARBLE (*Euchloe ausonides insulanus*)

Conservation Status and Concern

The Island Marble is a rare butterfly, restricted to two San Juan Islands. Petitioned for listing under the ESA in 2012, the USFWS found "listing the island marble butterfly as an endangered species may be warranted.".

Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend	Climate Vulnerability
In review	Candidate	Yes	G5T1	S1	Critical/declining	Moderate-high

Biology and Life History

Photo: T. Hanson

The Island Marble is a univoltine butterfly; the adult flight period extends from approximately mid-April through late June. Adults feed on floral nectar, and more than 10 plant species have been documented as nectar sources, primarily of the mustard family (Brassicaceae). Species that serve as larval hosts include field mustard (*Brassica campestris)*, tall tumble-mustard (*Sisymbrium altissimum)*, and Menzies pepper-grass (*Lepidium virginicum* var. menziesii*).* Adults regularly travel from their natal patches and have been observed flying a mile or more. Island Marble females lay eggs on the flowers of specific mustard species, and when egg-laying are selective about individual plants, location within mustard patches, and at the micro-scale, flower phenology and the location on plants. Larvae feed on flowers, pedicels and developing fruits through five growth stages (instars) before leaving the host plant and making their way through the plant canopy in search of pupation sites. Pupation sites are located above the ground on senesced grasses or other low vegetation, within 25 feet of their hostplant. This species spends the majority of its annual life cycle (July to April), including winter as a pupa (chrysalis). Larval survival is low (six percent to fifth instar), with threats including predation (especially by spiders), browsing deer, human disturbance, and weather events.

Distribution and Abundance

The Island Marble was found in a total of four distinct populations at 52 sites on San Juan and Lopez islands. It was originally known from only 14 specimens collected on Vancouver and Gabriola Islands in southwestern British Columbia, between 1861 and 1908. It was believed extinct, and then rediscovered at the San Juan Island National Historical Park in 1998, and formally described in 2001. WDFW surveys found that most Island Marble sites and populations discovered early on are now extinct. The sole definitively extant population persists with an estimated 50 to 100 adults on the south end of San Juan Island.

Habitat

The Island Marble inhabits open grasslands, disturbed sites, and herbaceous or sparsely vegetated habitats including native prairie, fields and pastures, sand dunes, gravel pits, and marine beach and lagoon margins where their annual hostplants persist. Extensive research has been conducted on the host patch characteristics selected by females for egg-laying.

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Island Marble: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
1	Invasive and other problematic species	Black-tailed deer abundance and extensive herbivory of hostplants and eggs/larvae	Erect deer-exclusion fences in areas of habitat	Current insufficient	Both
2	Agriculture and aquaculture side effects	Development of commercial fields of butterfly's host within area occupied, that serve as ecological traps	Consider planning for zones that would exclude large-scale farming of hostplant as a crop	Nothing current - new action needed	Both

NOTE: Numbers are for reference only and do not reflect priority.

MONARCH BUTTERFLY (*Danaus plexippus*)

Conservation Status and Concern

The Monarch butterfly faces significant threats in both summer and winter habitats, and action is needed to restore populations. Western Monarchs, including those breeding within Washington, have declined by more than 50 percent since 1997.

Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend	Climate Vulnerability
In review	None	No	G4	S4	Low/declining	Moderate

Biology and Life History


Photo: D. Ramsev

Monarchs, once common throughout the United States, undertake a spectacular multi-generational migration of thousands of miles between their northern breeding areas and overwintering areas in interior montane Mexico and coastal California. Most Monarchs that breed west of the Rocky Mountains, including in Washington State, overwinter in California. The life cycle of the Monarch butterfly is directly intertwined with their milkweed host (genus *Asclepias*). Monarchs lay their eggs on milkweed species, and resulting larvae and pupae develop on these plants. The milkweed plants' chemical defense compounds are accumulated in Monarch larvae, pupae, and adults and used to defend against their predators. The duration of complete development (from egg to adult) is dependent on weather conditions and can vary from 25 days to seven weeks. Like most butterflies, Monarch adults rely on floral nectar for nutrition. Although Monarchs are dependent on temperate zones for reproduction, the adults cannot survive freezing temperatures. Late summer adults undergo a physiological transformation to fat-storing, non-reproductive butterflies. They commence movements south (often in groups) to overwintering sites, covering an average of 25 to 30 miles per day, stopping at night, to feed, and during inclement weather. During spring migration, Monarchs typically do not travel in groups. They make their way north through subsequent generations until late summer.

Distribution and Abundance

Monarchs occur throughout most of the United States, southern Canada, and northern Mexico. In Washington, they are found east of the Cascades where milkweed occurs. Estimates of the historic California wintering population range from 1 million to 10 million butterflies. Monarchs have undergone an enormous decline in numbers in both eastern and western populations. The California overwintering population dropped from an estimated 1.2 million butterflies in 1997 to 200,000 in 2013. The number of Monarchs in Washington State is relatively low. Milkweeds are patchily distributed within the Columbia Basin. Monarchs migrating south through Washington often concentrate along the large river courses of the Columbia and Snake Rivers.

Habitat

Monarchs breed and travel through Washington but do not overwinter in the state. Monarchs require secure patches of milkweed and nectar resources during breeding, roosting sites and safe travel corridors for migration. Milkweeds and Monarchs in Washington occur in weedy fields and sparsely vegetated habitats, typically near wetlands or riparian areas. Southbound travel corridors, often river courses, need abundant late season nectar and trees for roosting at night and during periods of inclement weather.

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Monarch Butterfly: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
1	Resource information collection needs	Out of date and incomplete information on distribution	Conduct inventory and revisit historic locales (E WA)	Nothing current - new action needed	Both
2	Education needs	Hostplants are often targeted for removal by herbicide and mechanical methods	Habitat management planning	Nothing current - new action needed	Both

NOTE: Numbers are for reference only and do not reflect priority.

TAYLOR'S CHECKERSPOT (*Euphydryas editha taylori*)

*See Appendix B for a range and potential habitat distribution map

Conservation Status and Concern

This subspecies is currently restricted to a small scattering of eight populations in Washington, a single population in British Columbia, and two populations in Oregon. The decline of Taylor's Checkerspot has accompanied the loss of open prairie and grassland habitats. Taylor's Checkerspot was listed by the Washington Fish and Wildlife Commission as endangered in 2006, and listed endangered federally by the USFWS in 2013.

Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend	Climate Vulnerability
Endangered	Endangered	Yes	G5T1	S1	Critical/stable	Moderate-high

Biology and Life History


Photo: WDFW

Taylor's Checkerspot, a subspecies of Edith's Checkerspot, is a medium-sized butterfly with a striking checkered pattern of orange to brick red, black and cream. They complete one life cycle each year, and inhabit their sites year-round as eggs, larvae, pupae and adults. Adults emerge from pupation in the spring and feed on floral nectar from a variety of plants, often specializing on a few plant species. Adults mate and females subsequently lay eggs in clusters on plants in the family Plantaginaceae, primarily English plantain (*Plantago lanceolata)* and members of the Scrophulariaceae, primarily harsh paintbrush (*Castilleja hispida).* Eggs hatch in eight to nine days, and the resulting caterpillars (larvae) create webbing and feed communally through the spring on the hostplant species. Larvae enter a dormant phase (diapause) in late June to early August (exact timing dependent upon site conditions) when hostplants are no longer palatable. Larvae often diapause in a sheltered location under rocks, logs, or litter. The diapause phase lasts from summer until late winter (late January to late March). Upon breaking diapause, Checkerspot larvae resume feeding more broadly on oviposition plants and additional food sources (including sea blush (*Plectritis congesta*) and blue-eyed Mary (*Collinsia parviflora*). After spending nine to 10 months as larvae, they progress into pupae in late March through early May. Adults emerge two weeks later and live for a few days to two weeks.

Distribution and Abundance

In Washington, the species was historically found on over 80 grassland sites from southeastern Vancouver Island, British Columbia through the southern Willamette Valley in Oregon. Taylor's Checkerspot is now restricted to a handful of populations; six populations are found in Clallam County on the northeastern Olympic Peninsula, and a single population persists in the south Puget Sound region, located on the Joint Base Lewis-McChord (JBLM). Efforts are currently underway to reestablish the butterfly on three south Sound sites. The Clallam County sites have populations of 1,000 or more butterflies on two sites, with more modest numbers at four others. The JBLM site has been estimated at >10,000 individuals.

Habitat

Taylor's Checkerspot inhabits short-stature grasslands in low-elevation prairies and meadows, old forest clearings, coastal meadows and stabilized dunes, and montane meadows, and balds. A study in Oregon found that Taylor's Checkerspots selected habitat for egg-laying that occurred within high cover of short-stature native bunchgrasses and adult nectar resources, indicating that females select egg-laying sites based on habitat condition. The British Columbia study population had multiple hostplant species available and females' selection of egg-laying sites in this environment was influenced by hostplant phenology and condition. Characteristics of egg-laying habitat consistently identified in the British Columbia and three Olympic Peninsula populations were abundance (number or percent cover) and density of hostplants.

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Taylor's Checkerspot: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
1	Invasive and other problematic species	Invasive plants, those currently here, and many yet to come in the future, out-compete native grassland species, and otherwise make habitat unsuitable	Using herbicide, fire, and mechanical methods to restore native prairie	Current insufficient	Both
2	Invasive and other problematic species	Invasive plants, those currently here, and many yet to come in the future, out-compete native grassland species, and otherwise make habitat unsuitable	Planting/seeding native prairie species	Current insufficient	Both
3	Invasive and other problematic species	Trees and shrubs encroaching on habitat in forest matrix sites, primarily within Clallam Co, due to long-term fire suppression	Remove invading trees and shrubs	Current insufficient	Both
4	Fish and wildlife habitat loss or degradation	Only a few, small and disjunct populations remain in the south Sound region.	Reintroduce at restored prairie sites	Current sufficient	WDFW
5	Fish and wildlife habitat loss or degradation	Military training on JBLM that is poorly timed or placed and significantly impacts populations	Develop best management practices for areas occupied by butterfly within JBLM	Current insufficient	Both

NOTE: Numbers are for reference only and do not reflect priority.

Family Lycaenidae: GOSSAMER WING BUTTERFLIES

Conservation Status and Concern

Seven lycaenid butterflies were recognized as SGCN due to their rare and restricted hostplants and habitat types, small number of isolated populations, highly limited range and distribution, and threats to their habitat.

Common Name (Scientific name)	Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend
Makah Copper (*Lycaena mariposa charlottensis*)	None	Candidate	Yes	G5T5	S2	Low/declining
Golden Hairstreak (*Habrodais grunus herri*)	None	Candidate	Yes	G4G5	S1	Critical/declining
Johnson's Hairstreak (*Callophrys johnsoni*)	None	Candidate	Yes	G3G4	S2S3	Low/unknown
Juniper Hairstreak (*Callophrys gryneus* Columbia Basin segregate)	None	Candidate	Yes	G5TU	S2?	Low/unknown
Hoary Elfin (*Callophrys polios* Puget Trough segregate)	None	Monitor	No	G5T2T3	S2S3	Critical/declining
Puget (Blackmore's) Blue (*Icaricia icarioides blackmorei*)	None	Candidate	Yes	G5T3	S2	Low/declining
Straits Acmon Blue (*Icaricia acmon sp.*)	None	None	No	G5T?	SNR	Critical/declining

CLIMATE VULNERABILITY RANKING	
Common Name (Scientific name)	Ranking
Makah Copper *(Lycaena mariposa charlottensis)*	Moderate-high
Golden Hairstreak *(Habrodais grunus herri)*	N/A
Johnson's Hairstreak *(Callophrys johnsoni)*	Moderate-high
Juniper Hairstreak *(Callophrys gryneus Columbia Basin segregate)*	Moderate
Hoary Elfin *(Callophrys polios Puget Trough segregate)*	Low-moderate
Puget (Blackmore's) Blue *(Icaricia icarioides blackmorei)*	Alpine populations - High Low elevation populations - Low-moderate
Straits Acmon Blue (*Icaricia acmon sp.)*	Moderate-high

Taxonomic note: Genera synonyms: Hairstreak *Callophrys* = *Mitoura*; Elfin *Callophrys* = *Incisalia*; Blue *Icaricia* = *Plebejus*; Straits Acmon Blue was discovered in 2005.

Biology and Life History

Hoary Elfin perched in kinnikinnick on south Puget Sound prairie. Photo: R. Gilbert

The Lycaenidae butterfly family consists of small and often brightly colored species with the common names: copper, hairstreak, elfin, and blue. Lycaenid butterfly SGCN complete a single life cycle annually (univoltine), except Straits Acmon Blue which has two generations per year (spring and late summer). All are sedentary butterflies and do not migrate; instead, the species inhabits sites year-round (as egg, larva, pupa and adult), typically moving within only a few hundred yards of their natal locations. Adults emerge from their chrysalids (pupae) during species-specific time periods (See Table 1). Males begin emergence first, followed by females; late season individuals are primarily or solely females. Weather influences butterfly emergence and the flight period duration, with wet or cold conditions potentially delaying emergence, and warm, dry conditions promoting earlier emergence. Male lycaenids seek mates using patrolling patterned flight or perching on vegetation in select spots and darting out to inspect passing butterflies. Females search for egg-laying sites by slowly flying and hovering above hostplant vegetation, and then landing and crawling to inspect vegetation before depositing eggs singly. Both males and females feed by using their long proboscis to sip floral nectar. Males of most species require salts, which they obtain from evaporated puddles and moist soil and animal urine and feces. Larvae are slug-like in appearance and highly camouflaged in their host species. Many lycaenid larvae engage in mutualistic relationships with ants, known as myrmecophily, which typically consists of ants tending and milking larvae, obtaining nutrition in the form of a nectar-like substance (honeydew) in the process, and also protecting larvae from predators and parasitoids; in some situations the ants move butterfly larvae or pupae into ground chambers, including their nests. Ant interactions have been observed with Golden Hairstreak and Puget Blue; however, more study is needed to determine the extent of interaction and ecological significance of ant-larval relationships in these species. The overwintering stage varies by species: Makah Copper and Golden Hairstreak overwinter as eggs; Puget Blue as larvae; and Johnson's and Juniper Hairstreaks, and Hoary Elfins as pupae. The overwintering stage is not known for Straits Acmon Blue.

Key life history attributes for Washington populations of lycaenid butterfly SGCN.

Species	Adult Period	Hostplants	Primary Nectar Plants
Makah Copper	Jul-Aug	Bog cranberry (*Vaccinium oxycoccos*)	Swamp gentian (*Gentiana douglasiana*)
Golden Hairstreak	Aug-Sep	Golden chinquapin (*Chrysolepis chrysophylla*)	Late-summer flowers in tree canopy and herbaceous forest edge
Johnson's Hairstreak	Jun-Jul	Western dwarf mistletoe (*Arceuthobium campylopodum)*	Variety of herbaceous and shrub, mid-summer flowering plants
Juniper Hairstreak	Apr-May	Western juniper (*Juniperus occidentalis*)	Unknown
Hoary Elfin	Apr-May	Kinnikinnick (*Arctostaphylos uva-ursi*)	Kinnikinnick
Puget (Blackmore's) Blue	Jun-Jul	Sickle-keeled lupine, broadleaf lupine (*Lupinus albicaulis, L. latifolius*)	Host lupine
Straits Acmon Blue	May-Jun; Aug	Black knotweed (*Polygonum paronychia*)	Unknown

Distribution and Abundance

The distributions of these species are limited in part by a combination of their dependence on rare hostplant occurrence within rare habitat types. Their distribution and abundance in Washington is characterized by small numbers of small isolated populations. Recent survey efforts have been undertaken in Washington to determine the current distribution of Makah Copper, Golden Hairstreak, Johnson's Hairstreak, Hoary Elfin, Puget Blue, and Straits Acmon Blue. Still, little is known of the current distribution of Johnson's Hairstreak and Juniper Hairstreak, and of Hoary Elfin on the Kitsap Peninsula. Species overall range in Washington and estimated number of populations are summarized in Table 2.

Overall range; Washington counties and estimated number of extant populations for lycaenid butterfly SGCN.

Species	Range-Overall	Counties in WA	Est # Pop in WA
Makah Copper	Outer coast and low-elevation Olympic Peninsula, WA	Clallam, Grays Harbor, Jefferson, Mason,	10-15
Golden Hairstreak	Disjunct, and limited by chinquapin host: N Oregon Cascades; small area in Oregon Coast Range; small area in S WA Cascades	Skamania	1-2
Johnson's Hairstreak	Mature forests in SW British Columbia; western WA; W Oregon and N California	Jefferson, Lewis, Mason, Pierce, Skamania, Snohomish	5-10? Few recent detections

Juniper Hairstreak	Scattered in central Columbia Basin: SE WA; NE Oregon	Asotin, Columbia, Douglas, Franklin, Garfield, Grant, Klickitat	5-10? Few recent detections
Hoary Elfin	South Puget Sound region	Kitsap, Mason, Pierce, Thurston	10-15
Puget (Blackmore's) Blue	S Vancouver Is, British Columbia; eastern Olympic Mountain range, south Puget Sound region, WA	Clallam, Grays Harbor, Jefferson, Mason, Pierce, Thurston	7-10 (S Puget Sound), 30-40 (Olympic Mountains)
Straits Acmon Blue	Coastal WA: Straits of Juan de Fuca	Clallam	3

Habitat

These species inhabit a wide diversity of ecological systems, from forests to prairies, all of which are rare and declining. Hostplants for these butterflies are also rare, uncommon, or ecologically restricted. This species group includes butterflies that use tree or tree-growing (mistletoe) hostplants and inhabit the forest canopy (Golden Hairstreak, Johnson's Hairstreak, Juniper Hairstreak), as well as prostrate, woody shrub-dependent species (Makah Copper, Hoary Elfin, Straits Acmon Blue), and an herbaceous plant (lupine) feeder (Puget Blue) (see Table 1). Research is needed on all species to understand their life history and quantify specific habitat requirements including vegetation structure, food plant size and density, and key habitat features.

Makah Copper: A coastal *Sphagnum* bog obligate, this butterfly's hostplant is bog cranberry, a prostrate, vine-like, dwarf evergreen shrub. Both butterfly and host occur within 20 miles of the outer coast and Salish Sea. Bogs in this region are small, low elevation patches dominated by *Sphagnum* mosses and other bog-specific herbaceous plants and shrubs within an otherwise heavily forested landscape.

Golden Hairstreak: Confined to the few small patches of golden chinquapin, a broadleaf evergreen tree that occurs in low to middle elevations in southern Skamania County, the northern extent of the species' range. The Golden Hairstreak spends much of its adult life, and all of its egg, larval, and pupal life stages in the open forest canopy of chinquapins. Small, adjacent forest openings in this landscape often provide additional floral nectar sources and puddling sites. Beyond their chinquapin host requirement, little is known of their habitat needs.

Johnson's Hairstreak: This butterfly depends on western dwarf mistletoe, a plant that parasitizes old-growth western hemlock (*Tsuga heterophylla*) trees. Eggs are laid and larvae feed on western dwarf mistletoe, which typically grows high up in its host tree. Western hemlock occurs in low to middle elevations; Johnson's Hairstreak has been found in western Washington forests from 100 to 2500 feet in elevation. Small, adjacent forest openings in this landscape often provide additional floral nectar sources and puddling sites.

Juniper Hairstreak: Inhabits low to middle elevation, Columbia River Basin shrub-steppe where stands of its host western juniper, a short evergreen tree, occur. Nectaring occurs on spring flowering shrub-steppe plants in close proximity to host junipers. The Juniper Dunes Wilderness (Bureau of Land Management) in Franklin County is one of the few Washington locations where the species can reliably be found. Beyond their juniper host need, little is known of their habitat requirements.

Hoary Elfin: This species' hostplant, kinnikinnick, is a short, prostrate, evergreen woody shrub, relatively common at most elevations in western Washington; however the butterfly occurs only at low elevations on glacial outwash prairies and forest opening balds in the south Puget Sound region and early successional scrub-heath habitats (including forest clearings) on the Kitsap Peninsula. Hoary Elfin habitat across all regions is open or located at forest edge.

Puget (Blackmore's) Blue: Inhabits low elevation grasslands (prairies) in south Puget Sound, and sub-alpine meadows in the Olympic Mountains. The perennial sickle-keeled lupine is the larval host and primary adult nectar source for the Puget Blue on two south Sound prairies. The butterfly's dependence on sickle-keeled lupine limits their habitat to areas and sites that support significant patches of this plant. Density of host lupine across two Puget Blue varied between years and sites from 0.08-0.48 plants per square yard. Another important habitat feature is bare ground depressions where water collects and evaporates during the adult flight period; males rely on these sites to obtain minerals (puddling). There have been no studies of habitat requirements for sub-alpine Olympic Mountain Puget Blue populations.

Straits Acmon Blue: This Acmon Blue subspecies is restricted to a few coastal sand spits and beaches along the southern shores of the Straits of Juan de Fuca, in Clallam County where it uses the semi-shrubby, prostrate, black knotweed for its host. Beyond their host need and sand spit and beach occurrence, little is known of their habitat requirements.

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Family Lycaenidae: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
Makah Copper					
1	Agriculture and aquaculture side effects	Bog/fen obligate; habitat and species are vulnerable to alteration of local hydrology from logging and road building	Leading or participating in land use planning for rural, urban, and forestry lands	Current insufficient	Both
2	Resource information collection needs	Species in WA likely distinct subspecies	Genetic study to determine if WA populations are distinct subspecies	Nothing current - new action needed	Both
Golden Hairstreak					
1	Agriculture and aquaculture side effects	Habitat and hostplant, a rare tree/shrub occurs in areas with active logging practices	Develop plan with landowners to manage sites for butterfly, host, and habitat	Nothing current - new action needed	Both
2	Resource information collection needs	Current distribution unknown	Identify host patches and survey for butterfly	Current insufficient	Both
3	Resource information collection needs	Need to identify habitat needs, including optimal canopy cover in order to manage for species	Study habitat selection and requirements and use this information to develop management plans	Nothing current - new action needed	Both
Johnson's Hairstreak					
1	Agriculture and aquaculture side effects	Species habitat is low-elevation, old-growth forest that has been impacted by logging	Habitat management planning that recognizes importance of forest type and mistletoe species	Current insufficient	External
2	Resource information collection needs	Lacking information on current status of known sites and distribution	inventory; status assessment	Current insufficient	Both
Juniper Hairstreak					
1	Resource information collection needs	Lacking information on current status of known sites and distribution	Inventory; status assessment	Nothing current - new action needed	WDFW
2	Fish and wildlife habitat loss or degradation	Juniper woodlands are threatened with development, unsustainable grazing practices, ORV use, etc.	Habitat management planning that recognizes importance of juniper woodlands	Current insufficient	External
Hoary Elfin					
1	Fish and wildlife habitat loss or degradation	Development destroying prairie habitat	Species and habitat management plans for occupied sites	Current insufficient	Both

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
2	Fish and wildlife habitat loss or degradation	Development destroying prairie habitat, including highway building	Purchase and protect prairie sites	Current insufficient	Both
3	Invasive and other problematic species	Invasive plants, those currently here, and many yet to come in the future, out-compete native grassland species, and otherwise make habitat unsuitable	Using herbicide, fire, and mechanical methods to restore native prairie	Current insufficient	Both
4	Invasive and other problematic species	Invasive plants, those currently here, and many yet to come in the future, out-compete native grassland species, and otherwise make habitat unsuitable	Planting/seeding native prairie species	Current insufficient	Both
5	Resource information collection needs	Knowledge of current distribution is incomplete	Conduct surveys to determine current status and distribution of populations, especially needed on the Kitsap Peninsula	Nothing current - new action needed	WDFW
Puget (Blackmore's) Blue					
1	Resource information collection needs	Knowledge of current distribution is incomplete	Conduct surveys to determine current status and distribution of populations, primarily needed on the Kitsap Peninsula and northeast Olympic Peninsula	Nothing current - new action needed	Both
2	Invasive and other problematic species	Invasive plants, those currently here, and many yet to come in the future, out-compete native grassland species, and otherwise make habitat unsuitable	Using herbicide, fire, and mechanical methods to restore native prairie	Current insufficient	Both
3	Invasive and other problematic species	Invasive plants, those currently here, and many yet to come in the future, out-compete native grassland species, and otherwise make habitat unsuitable	Planting/seeding native prairie species	Current insufficient	Both
Straits Acmon Blue					

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
1	Climate change and severe weather	Populations located adjacent to marine waters- that are rising	Evaluate landscape and develop plan to increase habitat area and habitat heterogeneity in currently occupied sites and within occupied landscapes	Nothing current - new action needed	Both
2	Invasive and other problematic species	Invasive plants, those currently here, and many yet to come in the future, out-compete natives and otherwise make habitat unsuitable	Using herbicide and mechanical methods to maintain open condition of vegetation	Nothing current - new action needed	Both

NOTE: Numbers are for reference only and do not reflect priority.

Subfamily Heliconiinae: FRITILLARY BUTTERFLIES

*See Appendix B for range and potential habitat distribution maps for the Oregon and Valley Silverspots

Conservation Status and Concern

These species were recognized as SGCN in Washington due to their rare and restricted hostplants and habitat types, small number of isolated populations, limited range and distribution, and known threats to their habitats.

Common Name (Scientific name)	Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend
Puget Sound Fritillary (*Speyeria cybele pugetensis*)	None	None	No	G5TU	S3?	Low/declining
Valley Silverspot (*Speyeria zerene bremnerii*)	None	Candidate	Yes	G5T3T4	S2S3	Critical/declining
Oregon Silverspot (Speyeria zerene *hippolyta***)**	Threatened	Endangered	Yes	G5T1	SX	Extirpated
Meadow Fritillary (*Boloria bellona toddi*)	None	None	No	GNR	SNR	Low/declining
Silver-bordered Fritillary (*Boloria selene atrocostalis*)	None	Candidate	Yes	GNR	SNR	Low/declining

CLIMATE VULNERABILITY RANKING	
Common Name (Scientific name)	Ranking
Puget Sound Fritillary *(Speyeria cybele pugetensis)*	Low-moderate
Valley Silverspot (*Speyeria zerene bremnerii)*	Low-moderate
Oregon Silverspot (*Speyeria zerene hippolyta)*	Moderate
Meadow Fritillary (*Boloria bellona toddi)*	Low-moderate
Silver-bordered Fritillary (*Boloria selene atrocostalis)*	Moderate-high

Biology and Life History

Puget Sound Fritillary
Photo: R. Gilbert

The Heliconiinae (Fritillary) subfamily consists of medium and large sized butterflies with distinctive black line and dot patterning on bright orange dorsally, and a heavily-patterned ventrum with silvery orbs (genus *Speyeria:* greater fritillaries) or muted colored triangles (genus *Boloria*: lesser fritillaries). The greater fritillaries (genus *Speyeria*) complete a single life cycle annually (univoltine), while the lesser fritillaries (genus *Boloria*) have two generations per year (spring and late summer). All are sedentary butterflies and do not migrate; instead, the species inhabits sites year-round (as egg, larva, pupa and adult). Adults emerge from their chrysalids (pupae) during species-specific time periods; typically early-to-late summer for *Speyeria,* and both spring and late summer for *Boloria*. Males begin emergence first, followed by females; late season individuals are primarily or solely females. Weather influences butterfly emergence and flight period duration, with wet or cold conditions potentially delaying emergence. Male fritillaries seek mates using rapid patrolling and searching flight behavior. Females search for egg-laying sites by slowly flying and hovering above hostplants and then landing and crawling to inspect vegetation before depositing eggs singly. Both males and females feed by using their long proboscis to sip floral nectar. Research on other *Speyeria* spp. suggests that nectar availability affects the number of eggs laid by females. These species depend on violets (genus *Viola*) for their hostplants. *Speyeria* fritillaries lay eggs late in the summer. A tiny larva hatches within a few weeks and seeks shelter to overwinter, but does not feed until the following spring. In *Boloria* fritillaries, the first (spring) generation of eggs mostly develops quickly, resulting in the second (summer) generation. Larvae from this second generation develop slowly and are the overwintering form for these butterflies. Fritillary larvae are generally dark with many bristled spines, and feed nocturnally; these characteristics, along with a gland that secretes defensive chemicals, protect larvae from predators.

Distribution and Abundance

The distribution of these species is limited in part by their dependence on rare habitat types. Their distribution and abundance in Washington is characterized by low numbers of small isolated populations. The Oregon Silverspot has been extirpated from Washington, though habitat has been restored and plans have been made to reintroduce this species. Declines in both the number and size of populations have been documented for the other four species. Surveys were recently conducted to determine the current distribution of the Puget Sound Fritillary and Valley Silverspot in the south Puget Sound region, and Meadow and Silver-bordered Fritillary in northeastern Washington. Little is known of the current status and distribution of these species in other portions of their range within the state. Species overall range, Washington counties, and estimated number of populations are summarized in Table 1.

Table 1. Overall range; Washington counties and estimated number of extant populations for fritillary butterfly SGCN.

Species	Range-Overall	Counties in WA	Est # Pop in WA
Puget Sound Fritillary	Scattered populations: W Oregon; SW WA; montane NE Olympic Mountains, WA	Clallam, Clark, Cowlitz, Lewis, Mason, Pierce, Skamania, Thurston	15-20
Valley Silverspot	Scattered populations: SW WA; south Puget Sound region, WA; montane NE Olympic Mountains, WA; San Juan Islands, WA; southern Vancouver Island, Canada. Extirpated from Oregon.	Clallam, Cowlitz, Jefferson, Lewis, Pierce, Thurston	10-15
Oregon Silverspot	Coastal Oregon and Northern CA	Grays Harbor, Pacific	Extirpated from WA
Meadow Fritillary	Okanogan Highlands: British Columbia, Canada and northeastern WA	Ferry, Okanogan *possible* Stevens, Pend Oreille	5-10 (few recent detections)
Silver-bordered Fritillary	Scattered populations: E Oregon; E WA; N Idaho; NW Montana; E British Columbia; W Alberta	Grant, Lincoln, Okanogan, Pend Oreille, Stevens, Whitman	15-20 (few recent detections)

Habitat

These species inhabit a wide diversity of ecological systems, from coastal dunes to native prairies, boreal bogs, and aspen meadows, all of which are rare and declining. Research is especially needed for the Meadow and Silver-bordered Fritillaries to understand and quantify specific habitat requirements including vegetation structure, food plant size and density, and key habitat features.

Puget Sound Fritillary: Relies on open habitats in western Washington where its host violets grow, including montane meadows in the northeastern Olympic Mountains, and low-elevation river and creek courses, forest openings, and native grasslands. Egg-laying has been observed in the south Puget Sound region on two violet species (*V. praemorsa* and early blue violet, *V. adunca*). Adults require late-season nectar, and especially seek out native and non-native thistles (*Cirsium).* There have been no hostplant or habitat studies in Olympic Mountain populations.

Valley Silverspot: Restricted to native grasslands in western Washington, primarily montane meadows in the northeastern Olympic Mountains, and low-elevation, short-stature grasslands in the south Puget Sound region. In a two-year study of Valley Silverspot habitat and nectar use on two south Sound prairies, early blue violet was identified as a larval host, and two plants were selected for adult nectar sources (showy fleabane, [*Erigeron speciosus*] and Canada thistle [*C. arvense*]). There have been no hostplant or habitat studies in Olympic Mountain populations.

Oregon Silverspot: Uses open, short-stature grasslands in coastal dunes, bluffs, and nearby forest glades. Habitat studies have been conducted for this butterfly on the remaining sites in Oregon; early blue violet is the sole hostplant for this butterfly, and females selected patches with more than 20 plants per square yard for egg-laying sites. Although the Oregon Silverspot has been extirpated from Washington, WDFW has led habitat restoration efforts on coastal sites in Pacific County in preparation for future butterfly reintroductions.

Meadow Fritillary: Inhabits meadows, forest openings, and riparian corridors in aspen and pine woodlands between 2000 to 4500 feet in elevation in northeastern Washington. Another violet host butterfly, it is found with the white-flowering Canada violet (*V. canadensis*). Beyond their violet host need, little is known of their habitat requirements.

Silver-bordered Fritillary: This butterfly is dependent on fen and *Sphagnum* bog sites located in the xeric steppe and open forests of the Columbia River Basin. Bogs in this region are small, mid-elevation patches dominated by *Sphagnum* moss species and other bog-specific herbaceous plants and shrubs. Their hostplants are unknown violet species, likely marsh violet (*V. palustris*) and bog violet (*V. nephrophylla*). Beyond their fen and bog habitat restriction, little is known of their habitat requirements.

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Subfamily Heliconiinae: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
Puget Sound Fritillary					
1	Invasive and other problematic species	Invasive plants, those currently here, and many yet to come in the future, out-compete native grassland species, and otherwise make habitat unsuitable	Using herbicide, fire, and mechanical methods to restore native prairie	Current insufficient	Both
2	Invasive and other problematic species	Invasive plants, those currently here, and many yet to come in the future, out-compete native grassland species, and otherwise make habitat unsuitable	Planting/seeding native prairie species	Current insufficient	Both
3	Resource information collection needs	Knowledge of current distribution is incomplete	Conduct surveys to determine current status and distribution of populations, primarily needed on the Kitsap Peninsula and northeast Olympic Peninsula	Nothing current - new action needed	Both
4	Invasive and other problematic species	Trees and shrubs encroaching on habitat in forest matrix sites throughout range, due to long-term fire suppression	Remove invading trees and shrubs	Current insufficient	Both
Valley Silverspot					
1	Invasive and other problematic species	Invasive plants, those currently here, and many yet to come in the future, out-compete native grassland species, and otherwise make habitat unsuitable	Using herbicide, fire, and mechanical methods to restore native prairie	Current insufficient	Both
2	Invasive and other problematic species	Invasive plants, those currently here, and many yet to come in the future, out-compete native grassland species, and otherwise make habitat unsuitable	Planting/seeding native prairie species	Current insufficient	Both

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
3	Resource Information Collection Needs	Incomplete knowledge of distribution in NE Olympic Mountains	Conduct surveys to determine current status and distribution of populations in the WA southern Cascades	Nothing current - new action needed	WDFW
Oregon Silverspot					
1	Invasive and other problematic species	Invasive plants, those currently here, and many yet to come in the future, out-compete native grassland species, and otherwise make habitat unsuitable	Using herbicide, fire, and mechanical methods to restore native prairie	Current insufficient	Both
2	Invasive and other problematic species	Invasive plants, those currently here, and many yet to come in the future, out-compete native grassland species, and otherwise make habitat unsuitable	Planting/seeding native prairie species	Current insufficient	Both
3	Fish and wildlife habitat loss or degradation	No populations currently extant in WA	Reintroduce at restored sites	Nothing current - new action needed	Both
Meadow Fritillary					
1	Agriculture and aquaculture side effects	Intensive livestock use may cause direct harm to butterfly through trampling, and indirect harm by reducing host and nectar species and compacting soil	Install fencing to carefully manage or prohibit livestock access to occupied riparian areas	Nothing current - new action needed	Both
2	Invasive and other problematic species	Forest encroachment due to long-term fire suppression has reduced amount and quality of habitat. Hostplant is an herbaceous species and butterfly occupies open habitats	Remove invading trees and shrubs	Nothing current - new action needed	Both
3	Invasive and other problematic species	Invasive plants, those currently here, and many yet to come in the future, out-compete native grassland species, and otherwise make habitat unsuitable	Using herbicide, fire, and mechanical methods to restore meadows	Nothing current - new action needed	Both

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
Silver-bordered Fritillary					
1	Agriculture and aquaculture side effects	Intensive livestock use may cause direct harm to butterfly through trampling, and indirect harm by reducing host and nectar species and compacting soil	Install fencing to carefully manage or prohibit livestock access to occupied riparian areas	Nothing current - new action needed	Both
2	Invasive and other problematic species	Forest encroachment due to long-term fire suppression has reduced amount and quality of habitat. Hostplant is an herbaceous species and butterfly occupies open habitats	Remove invading trees and shrubs	Nothing Current - new action needed	Both
3	Invasive and other problematic species	Invasive plants, those currently here, and many yet to come in the future, out-compete native grassland species, and otherwise make habitat unsuitable	Using herbicide, fire, and mechanical methods to restore meadows	Nothing Current - new action needed	Both

NOTE: Numbers are for reference only and do not reflect priority.

Family Hesperiidae: SKIPPER BUTTERFLIES

*See Appendix B for a range and potential habitat distribution map for the Mardon Skipper

Conservation Status and Concern

These five butterflies in the Skipper Family were recognized as SGCN throughout their ranges due to the small number of isolated populations, specialized and restricted habitat, and known threats to their habitat.

Common Name (Scientific name)	Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend
Propertius Duskywing (*Erynnis propertius*) western Washington populations only	None	None	No	G5	S3	Low/declining
Oregon Branded Skipper (*Hesperia colorado* Salish Sea segregate)	None	None	No	G5T3T4	S2	Critical/declining
Mardon Skipper (*Polites mardon*)	None	Candidate	Yes	G2G3T2 T3	S1	Low/declining
Sonora Skipper (*Polites sonora siris*)	None	None	No	G4T3	S2S3	Critical/declining
Yuma Skipper (*Ochlodes yuma*)	None	Candidate	Yes	G5	S1	Critical/declining

CLIMATE VULNERABILITY RANKING	
Common Name (Scientific name)	Ranking
Propertius Duskywing (*Erynnis propertius*) western Washington populations only	Moderate
Oregon Branded Skipper (*Hesperia colorado* Salish Sea segregate)	Moderate
Mardon Skipper (*Polites mardon*)	Moderate-high
Sonora Skipper (*Polites sonora siris*)	Low-moderate
Yuma Skipper (*Ochlodes yuma*)	Moderate

Taxonomic note: Skipper butterflies are members of two subfamilies: Propertius Duskywing is a Pyrginae (dicot or spread-wing skippers); Oregon Branded, Mardon, Sonora, and Yuma Skipper are Hesperiinae (monocot or folded-wing skippers).

Biology and Life History

Propertius Duskywing
Photo: A. Barna

These skippers complete a single life cycle annually (univoltine). All are sedentary butterflies and do not migrate; instead, the species inhabits sites year-round (as egg, larva, pupa and adult), typically moving within only a few hundred meters of their natal locations. Adults emerge from their chrysalids (pupae) during species-specific time periods (See Table 1). Males begin emergence first, followed by females; late-season individuals are primarily or solely females. Weather influences butterfly emergence and the flight period duration, with wet or cold conditions delaying emergence. Male skippers seek mates by perching on low vegetation and then darting out to inspect passing butterflies. Males that detect females commence courtship behavior; when males detect another male they engage in a territory defense behavior of tight, upward spiraling flight. Females search for egg-laying sites by slowly flying and hovering just above hostplant vegetation and then depositing single eggs. Both males and females feed by using their long proboscis to sip floral nectar. Skipper larvae conceal themselves in silken shelters and primarily feed at night. Hesperiinae larvae create shelters formed by webbing their hostplant grass blades together, and their prepupal larvae construct strong silken shelters in hostplant grasses in which pupation occurs. Propertius Duskywing (Pyrginae Skipper) larvae construct large cocoons in folded oak leaves, which drop to the ground over the winter, where pupation occurs in early-spring. These species overwinter as larvae, except for Oregon Branded Skipper which survives the winter period in the egg stage.

Table 1. Key life history attributes for Washington populations of skipper butterfly SGCN.

Species	**Adult Period**	Hostplants	**Primary Nectar Plants**
Propertius Duskywing	Apr-May	Garry oak (*Quercus garryana*)	Common camas (*Camassia quamash*)
Oregon Branded Skipper	Jul-Aug	Unknown grass/sedge	Tansy ragwort (*Tanacetum vulgare*), white-top aster (*Sericocarpus rigidus*)
Mardon Skipper	May-Jun	Grasses/sedges (spp. are site specific)	Violets (*Viola*), common vetch (*Vicia sativa*)
Sonora Skipper	Jun-Jul	Unknown grass/sedge	Unknown
Yuma Skipper	Jun-Jul	Common reed (*Phragmites americanus*)	Unknown

Distribution and Abundance

These skippers primarily occur in a few small isolated populations. Though once common, large populations of these butterflies in Washington are extant today only for Mardon Skipper in the southeastern Cascades.

Table 2. Overall range; counties and estimated number of Washington populations for skipper butterfly SGCN.

Species	Range-Overall	Counties in WA	Est # Pop in WA
Propertius Duskywing (western Washington only)	Aligned with oak host distribution: SW British Columbia; south and north Puget Sound, WA; E slope Cascades, WA; W Oregon; south to NW California	Mason, San Juan, Skamania, Thurston	6-10
Oregon Branded Skipper	SW British Columbia; south and north Puget Sound, WA	Pierce, San Juan, Thurston	5
Mardon Skipper	Highly disjunct: South Puget Sound, WA; Southeast Cascades, WA; Southwest Oregon; NW California	Klickitat, Lewis, Pierce, Skamania, Thurston, Yakima	3 (S Puget Sound) 30-40 (SE Cascades)
Sonora Skipper	SW WA	Grays Harbor, Mason, Thurston	2-5?
Yuma Skipper	Highly disjunct: Columbia Basin, WA; SE Oregon; E Central California; Nevada; S Utah; E Colorado; N Arizona	Asotin, Grant, Klickitat	3-5?

Habitat

These species use rare and declining habitat types. Oregon Branded, Mardon, and Sonora Skippers inhabit glacial outwash prairies in western Washington that have been reduced to less than three percent of historical cover. Research is needed for all species to more accurately quantify specific habitat requirements including vegetation structure, food plant size and density, and key habitat features.

Propertius Duskywing: An obligate of Garry oak (*Quercus garryana*), this species Inhabits low-elevation (up to 2000 feet), open-canopied, oak woodlands and savannah. Oak woodlands are rare, patchily distributed, and declining in western Washington. Research is needed to determine the specific Garry oak understory requirements of Propertius Duskywing larvae for overwintering, and by pupae for their development.

Oregon Branded Skipper: In the south Puget Sound region, this species selects habitat within glacial outwash prairies dominated by short-stature native grasses and sedges, especially Roemer's fescue (*Festuca roemeri*) and long-stoloned sedge (*Carex inops*), with open structure, and abundant bare ground (or moss/lichen). The sole extant San Juan County population uses open meadows between 1500 to 2200 feet in elevation. Egg-laying has been observed on Roemer's fescue and long-stoloned sedge, however, their use as larval hostplants have not been confirmed with larval feeding.

Mardon Skipper: Inhabits glacial outwash prairies in the south Puget Sound region, and montane meadows 1800 to 5500 feet in elevation in the southeastern Cascade Mountain Range. In south Puget Sound grasslands, Mardon Skippers use open, grass dominated habitat with abundant Roemer's Fescue interspersed with early blue violet and select early blue violet and common vetch as nectar sources. Adult Mardon Skippers select for short, open-structured, native fescue grasslands, which provide access to nectar and oviposition plants and a requisite thermal environment. Mardon Skippers on two south Sound prairies oviposited on Roemer's fescue, and females selected for small, mostly green fescue plants, in sparse, short-statured, and open-structured vegetation. In the southeastern Cascade Mountains, Mardon Skippers are found in meadows in an otherwise forested landscape; a variety of grasses and sedges are used for egg-laying (and larval hosts) and females select for large, well developed plants. The historical and ongoing loss of montane meadow habitat is well-documented.

Sonora Skipper: Sonora Skipper inhabits glacial outwash prairies, forest glades, and road edges in southwest Washington lowlands. The hostplants for this species have not been identified, and habitat selection and suitability have not been studied.

Yuma Skipper: The native common reed is the known hostplant for this skipper which is limited to a few marshes in the xeric Columbia Basin steppe. To date, this butterfly has not been found in stands of the invasive, non-native common reed, although further surveys are needed to address this potential. Beyond their need for the native species of common reed, little is known of their habitat requirements.

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Family Hesperiidae: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
Propertius Duskywing					
1	Fish and wildlife habitat loss or degradation	Oak woodland requisite habitat still being developed	Review proposed projects and protect oak woodland and savanna habitat	Current insufficient	Both
2	Invasive and other problematic species	Oak woodland and savanna being invaded by non-native shrubs and grasses	Using herbicide, fire, and mechanical methods to restore native oak woodland and savanna	Current insufficient	Both
3	Invasive and other problematic species	Oak woodland and savanna being invaded by native trees, especially Douglas-fir	Remove invading trees	Current insufficient	Both
4	Resource Information Collection Needs	Knowledge of current distribution is incomplete	Revisit historic locales and search for new populations	Current insufficient	Both
Oregon Branded Skipper					
1	Invasive and other problematic species	Invasive plants, those currently here, and many yet to come in the future, out-compete native grassland species, and otherwise make habitat unsuitable	Using herbicide, fire, and mechanical methods to restore native prairie	Current insufficient	Both
2	Invasive and other problematic species	Invasive plants, those currently here, and many yet to come in the future, out-compete native grassland species, and otherwise make habitat unsuitable	Planting/seeding native prairie species	Current insufficient	Both
3	Resource information collection needs	Effectiveness of management is minimized by the little known of the habitat requirements for this butterfly	Conduct research to characterize the habitat selected by females for oviposition (multi-year).	Nothing current - new action needed	Both
4	Fish and wildlife habitat loss or degradation	Only a few, small and disjunct populations remain in the south Sound region	Reintroduce at restored prairie sites	Nothing current - new action needed	WDFW

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
Mardon Skipper					
1	Invasive and other problematic species	Invasive plants, those currently here, and many yet to come in the future, out-compete native grassland species, and otherwise make habitat unsuitable	Using herbicide, fire, and mechanical methods to restore native prairie	Current insufficient	WDFW
2	Invasive and other problematic species	Invasive plants, those currently here, and many yet to come in the future, out-compete native grassland species, and otherwise make habitat unsuitable	Planting/seeding native prairie species	Current insufficient	WDFW
3	Resource information collection needs	Knowledge of current distribution and site status in southern Cascades is incomplete	Conduct surveys to determine current status and distribution of populations in the WA southern Cascades	Current insufficient	Both
4	Invasive and other problematic species	Forest encroachment due to long-term fire suppression has reduced amount and quality of habitat. Hostplant is a grass, and species utilizes open meadows.	Remove invading trees and shrubs	Current insufficient	External
5	Fish and wildlife habitat loss or degradation	Only a few, small and disjunct populations remain in the south Sound region.	Reintroduce at restored prairie sites	Nothing current - new action needed	WDFW
6	Resource information collection needs	High likelihood south Sound and Cascades populations are distinct subspecies.	Genetic study to evaluate difference between south Sound and Cascades populations	Nothing current - new action needed	Both
7	Climate change and severe weather	Species vulnerable in south Sound to cool, wet spring weather; in Cascades to warm winters with low snowpack	Evaluate landscape and develop plan to increase habitat area and habitat heterogeneity in currently occupied sites and within occupied landscapes	Current insufficient	Both

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
Sonora Skipper					
1	Invasive and other problematic species	Invasive plants, those currently here, and many yet to come in the future, out-compete native grassland species, and otherwise make habitat unsuitable	Using herbicide, fire, and mechanical methods to restore native prairie	Current insufficient	Both
Yuma Skipper					
1	Management Decision Needs	State Parks and other land managers not aware that native Phragmites exists and is the host for this butterfly - so they often attempt to treat native Phragmites as a weed	Develop management plans specific to occupied sites	Current insufficient	Both
2	Resource information collection needs	Lack of data on current status and distribution	Determine distribution, population status	Nothing current - new action needed	WDFW

NOTE: Numbers are for reference only and do not reflect priority.

BUMBLE BEES

Genus *Bombus*: BUMBLE BEES

Conservation Status and Concern
Bumble bees have recently become the focus of conservation concern and efforts due to their precipitous population declines and prodigious capabilities as pollinators. In a recent status assessment, IUCN (International Union of Conservation of Nature) identified three Washington species as facing high or extremely high risk of extinction: Western Bumble Bee and Morrison's Bumble Bee were ranked Vulnerable, and Suckley Cuckoo Bumble Bee was ranked Critically Endangered.

Common Name (Scientific name)	Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend
Western Bumble Bee (*Bombus occidentalis*)	None	None	No	G2G3	S2S3	Low/declining
Morrison's Bumble Bee (*Bombus morrisoni*)	None	None	No	G4G5	SNR	Critical/unknown
Suckley Cuckoo Bumble Bee (*Bombus suckleyi*)	None	None	No	GH	SNR	Critical/declining

CLIMATE VULNERABILITY RANKING	
Common Name (Scientific name)	Ranking
Western Bumble Bee (*Bombus occidentalis*)	Moderate-high
Morrison's Bumble Bee (*Bombus morrisoni*)	Moderate
Suckley Cuckoo Bumble Bee (*Bombus suckleyi*)	Moderate

Biology and Life History
These three bumble bee species are from two distinct subgenera: Western and Morrison's Bumble Bees are classified within the *Bombus* subgenus, and Suckley Cuckoo Bumble Bee in the *Psithyrus* subgenus. Bees from these two subgenera have markedly different life histories. *Bombus* subgenus species live in small, highly social and interdependent colonies with structured roles: egg-laying females (queens), foraging and nesting females (workers), and males. Cuckoo bumble bees do not live in a social group, but use the nests and tending workers of social bumble bee species to reproduce. Suckley Cuckoo Bumble Bees use the nests of Western Bumble Bee and likely several other *Bombus* species. Bumble bee colonies are annual. In late-winter or early-spring, queens, which are the sole survivors from the previous year, emerge from their overwintering sites to feed on floral nectar, collect pollen, and search for suitable nest sites, which are often abandoned rodent holes. *Bombus* subgenus queens lay eggs in their individual nests and gather nectar and pollen to feed their first brood of workers. In the nest, eggs develop into larvae and then spin cocoons in which they pupate. Once they emerge from their cocoons, the workers then take over tending and provisioning young, while the queen continues to lay eggs, and


Morrison's Bumble Bee
Photo: H. V. Davis

typically no longer leaves the nest. Late in the season, the colony produces males and new queens which mate. Males, workers, and old queens eventually die; only the newly mated queens are capable of surviving through winter. Bumble bees are key generalist pollinators of native plants and agricultural crops. Through their foraging and collection of nectar and pollen they physically transfer the latter between plants, allowing them to reproduce. Their unique behavior of "buzz pollination", in which they grab onto and strongly shake an entire flower by vibrating their powerful wing muscles, results in large amounts of pollen being released and produces a more complete fruit set than other pollinators, including honey bees.

Distribution and Abundance

All three bumble bee species historically occurred in healthy populations across large geographic areas. Recent surveys reveal significant declines in their numbers, distribution, and ranges. Additional surveys are needed to determine the location and number of extant Washington populations for all three species, especially for Morrison's Bumble Bee and Suckley Cuckoo Bumble Bee.

> **Western Bumble Bee**: Historically common in the western United States and Canada: western South Dakota south to northern New Mexico west to northern California and north to southern Alaska. Recent surveys have located only a handful of populations in Washington, primarily in remote subalpine and montane sites. A 28 percent reduction was estimated in detected range-area in a recent study, and Western Bumble Bee was found largely absent from the western portion of its range (including Washington). Over the past decade, relative abundance of Western Bumble Bee populations is estimated to have declined approximately 50 percent, while Washington has experienced even greater decline.

> **Morrison's Bumble Bee**: Historical geographic range primarily within the intermountain western United States: northern Colorado south to northern Mexico west to southern California and north to southern British Columbia, Canada. Within Washington, Morrison's Bumble Bee occurred historically in the Columbia Basin; however, only a few recent sightings are known from this region. Many previously known strongholds for this bumble bee have been intensively surveyed in recent years without detection; the decline in rangewide relative abundance is estimated at 82.6 percent.

> **Suckley Cuckoo Bumble Bee**: Occurred historically in western Canada and the United States: southwestern Manitoba southwest to western South Dakota south to southern Colorado west to northern California north to the Yukon and Northwest Territories south to central British Columbia; a few populations have also been documented in eastern Canada. This cuckoo bumble bee historically was found throughout Washington. Recent rangewide surveys detected this species in only six localities, including one near far northeastern Washington.

Habitat

Bumble bees depend on habitats with rich floral resources throughout the nesting season, and many species select specific suites of plants for obtaining nectar and pollen. They also select flowers based on their structure and the bee's tongue length. For example, the short to medium length-tongued Suckley Cuckoo Bumble Bee uses shallow to medium-depth flowers. Bumble bees require above and below-ground micro-sites for overwintering and nesting, including logs, stumps, and abandoned rodent and ground-nesting bird nests. Their habitats must also be protected from insecticides. Bumble bees are adaptable; they do not require native vegetation. However, intensive agricultural development has been shown to result in regional bumble bee declines. Although habitat loss and insecticide use have played a role in bumble bee declines, their rapid and widespread declines even from apparently high quality habitats support the current prevailing hypothesis that pathogens introduced into the wild from commercial bumble bee facilities are the main factor in declines.

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Genus Bombus: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
Western Bumble Bee					
1	Agriculture and aquaculture side effects	Importation of bumble bees for use in pollination of commercial crops introduces pathogens into the wild	Review of federal/state policies that allow translocation and establishment of commercially-reared bumble bees in North America	Current insufficient	Both
2	Resource information collection needs	Lack of data on current status and distribution	Determine distribution, population status	Current insufficient	Both
Morrison's Bumble Bee					
1	Agriculture and aquaculture side effects	Importation of bumble bees for use in pollination of commercial crops introduces pathogens into the wild	Review of federal/state policies that allow translocation and establishment of commercially-reared bumble bees in North America	Current insufficient	Both
2	Resource information collection needs	Lack of data on current status and distribution	Determine distribution, population status	Current insufficient	Both
Suckley Cuckoo Bumble Bee					
1	Agriculture and aquaculture side effects	Importation of bumble bees for use in pollination of commercial crops introduces pathogens into the wild	Review of federal/state policies that allow translocation and establishment of commercially-reared bumble bees in North America	Current insufficient	Both
2	Resource information collection needs	Lack of data on current status and distribution	Determine distribution, population status	Current Insufficient	Both

NOTE: Numbers are for reference only and do not reflect priority.

MOLLUSKS

Family Oreohelicidae: MOUNTAINSNAILS

Conservation Status and Concern
Many mountainsnail species and subspecies have specialized habitat requirements and very restricted ranges, low ability to disperse, and are vulnerable to disturbances such as logging, fire, unsustainable grazing, or introduced predators. Most mountainsnail species and subspecies (roughly 91 percent) are considered imperiled or critically imperiled by NatureServe.

Common Name (Scientific name)	Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend
Chelan Mountainsnail (*Oreohelix sp. 1)*	In review	None	No	G2	S2	Critical/declining
Hoder's Mountainsnail (*Oreohelix n. sp.*)	None	None	No	GNR	SNR	Critical/declining
Mad River Mountainsnail (*Oreohelix n. sp.*)	None	None	No	GNR	SNR	Critical/declining
Ranne's Mountainsnail (*Oreohelix n. sp.*)	None	None	No	GNR	SNR	Critical/declining
Limestone Point Mountainsnail (*Oreohelix sp. 18* or *O. idahoensis baileyi)*	None	None	No	G1	SH	Critical/declining

CLIMATE VULNERABILITY RANKING	
Common Name (Scientific name)	Ranking
Chelan Mountainsnail (*Oreohelix sp. 1)*	Low-moderate
Hoder's Mountainsnail (*Oreohelix n. sp.*)	Low-moderate
Mad River Mountainsnail (*Oreohelix n. sp.*)	Low-moderate
Ranne's Mountainsnail (*Oreohelix n. sp.*)	Low
Limestone Point Mountainsnail (*Oreohelix sp. 18* or *O. idahoensis baileyi)*	Low-moderate

Taxonomic note: Many of the Oreohelicidae that are considered distinct species are not yet formally described, and it is likely that additional rare species of *Oreohelix* will be discovered with further investigation.

Biology and Life History

Mountainsnails are terrestrial gastropods of western North America. Mountainsnails eat leaf litter, detritus, and microorganisms on the surface of logs, rocks, or soil. They are hermaphroditic, having both male and female organs. They are live-bearers; the eggs hatch before leaving the uterus of the parent, and they raise their young within their shells until they reach a certain size. It is not known how long they live, or how often they reproduce.

Limestone Point Mountainsnail
Photo: from Jensen et al. 2012

Distribution and Abundance

Chelan Mountainsnail a.k.a. Tiny Canyon Mountainsnail (*Oreohelix sp. 1*): A local endemic of the eastern foothills of the Cascades in central Washington. Populations of the Chelan Mountainsnail are few, small, and scattered. Its known range covers about 270 square miles in eastern Chelan County. Within this area this snail has been found at less than 10 sites from about one-fourth acre to 10 acres in size. Most of the sites are scattered, ranging from less than one acre to a few acres in size, and only one individual was observed (seven sites destroyed in the 1994 Tyee Fire were those of the Entiat Mountainsnail, erroneously identified as this species). Sites scattered within an area roughly bounded by the Columbia River on the southeast, Lake Chelan on the northwest to include the Twentyfive Mile Creek drainage, then southwest to Tyee Mountain, south to Chumstick Mountain, and following the ridge south and southeast to Burch Mountain, then south to the confluence of the Wenatchee and Columbia Rivers. The USFWS is conducting a status review after a finding that it may warrant listing under the ESA.

Hoder's Mountainsnail: This species is only known from Dick Mesa, about 3.5 miles northeast of Entiat, Chelan County.

Mad River Mountainsnail: This species has only been collected at one site on the Mad River in the Entiat Valley, eastern Chelan County.

Ranne's Mountainsnail: This species is only known from one site of less than 10 acres on Dick Mesa, about 3 miles northeast of Entiat, Chelan County.

Limestone Point Mountainsnail: Known from Lime Point, Asotin County, WA, and the Seven Devils Mountains and Snake River Canyon below the mouth of the Salmon River, Idaho. At Limestone Point, empty shells are scattered over the northeastern slope; no living specimens have been found in Washington in recent years, but additional season appropriate surveys are needed.

Habitat

Oreohelix species are often associated with limestone outcrops, or areas with soil or rock with a fair percentage of lime.

Chelan Mountainsnail: Generally open Douglas-fir and ponderosa pine; this species has been found in two types of habitats broadly described as: 1) in schist talus, and 2) in litter or under shrubs in and adjacent to open dry forest stands with pinegrass or elk sedge understory. The typical site occurs within concave landforms that accumulate and maintain moisture more efficiently than the surrounding landscape. Elevations range from 1200 to 2600 feet; site aspect is variable.

Hoder's Mountainsnail: On or near ridgetop in grassland and timber edge, with buckwheat (*Eriogonum* sp.) and arrowleaf balsamroot (*Balsamorrhiza sagitta*).

Mad River Mountainsnail: In talus under black cottonwood (*Populus balsamifera*) or bigleaf maple.

Ranne's Mountainsnail: On southeasterly aspect near the ridgetop, in grassland with buckwheat and arrowleaf balsamroot.

Limestone Point Mountainsnail: Associated with limestone outcrops and talus at mid-elevations in arid land.

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Family Oreohelicidae: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
Chelan Mountainsnail					
1	Resource information collection needs	Need taxonomic clarification	Taxonomic clarification; delineate occupied habitat	Current insufficient	External
2	Fish and wildlife habitat loss or degradation	Fires; road building, unsustainable logging	Need to identify core habitat sites and protect alteration	Current insufficient	External
3	Invasive and other problematic species	Predation by wild turkeys	Increase turkey harvest, if needed	Nothing current - new action needed	WDFW
Hoder's Mountainsnail					
1	Agriculture and aquaculture side effects	Fires; road building	Develop management recommendations	Current insufficient	External

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
2	Invasive and other problematic species	Predation by wild turkeys	Increase turkey harvest, if needed	Current insufficient	WDFW
3	Resource information collection needs	Taxonomic uncertainty may mean one or more taxa are in greater decline	Need taxonomic clarification	Current insufficient	External
Limestone Point Mountainsnail					
1	Resource information collection needs	Need information; confirm still extant	Taxonomic and status clarification	Current insufficient	Both
Mad River Mountainsnail					
1	Agriculture and aquaculture side effects	Fires; road building; need taxonomic clarification	Delineate and protect occupied habitat	Current insufficient	Both
2	Resource information collection needs	Taxonomic uncertainty may mean one or more taxa are in greater decline	Taxonomic confirmation, description	Nothing current - new action needed	External
Ranne's Mountainsnail					
1	Resource Information collection needs	Taxonomic clarification	Formal species description; taxonomic clarification	Nothing current - new action needed	External
2	Agriculture and aquaculture side effects	Prescribed fires	Special management, or designation	Current insufficient	External
3	Agriculture and aquaculture side effects	Unsustainable grazing of mountainsnail habitat	Install fencing to carefully manage or prohibit livestock access to occupied riparian areas	Current insufficient	External
4	Invasive and other problematic species	Predation by wild turkeys	Increase turkey harvest, if needed	Nothing current - new action needed	WDFW

NOTE: Numbers are for reference only and do not reflect priority.

Family Polygyridae: FORESTSNAILS, DUSKYSNAILS, OREGONIANS, AND HESPERIANS

Conservation Status and Concern

These snails are of conservation concern because they have specialized habitat requirements, such as moist mature forest with a hardwood component, or moist sites in otherwise dry environments. Snails do not readily disperse and populations are isolated. They are vulnerable to disturbances or alteration of these sites, which may occur through logging, development, use of talus for road-building, or large ungulate grazing of springs.

Common Name (Scientific name)	Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend
Dry land forestsnail (*Allogona ptychophora solida*)	None	None	No	G5T2	S1S2	Low/unknown
Washington Duskysnail (*Amnicola sp. 2*)	None	None	No	G1	S1	Low/declining
Columbia Oregonian (*Cryptomastix hendersoni*)	In review	Candidate	Yes	G1G2	S1	Critical/declining
Puget Oregonian (*Cryptomastix devia*)	In review	None	No	G3	S2S3	Low/declining
Poplar Oregonian (*Cryptomastix populi*)	None	Candidate	Yes	G2	S1S2	Low/declining
Mission Creek Oregonian (*Cryptomastix magnidentata*)	None	None	No	G1	SNR	Low/unknown
[unnamed Oregonian] (*Cryptomastix mullani hemphilli*)	None	None	No	GNR	SNR	Low/unknown
Dalles Hesperian (*Vespericola depressa*)	None	None	No	G2Q	S1	Low/unknown

CLIMATE VULNERABILITY RANKING	
Common Name (Scientific name)	Ranking
Dry land forestsnail (*Allogona ptychophora solida*)	Low-moderate
Washington Duskysnail (*Amnicola sp. 2*)	Low-moderate
Columbia Oregonian (*Cryptomastix hendersoni*)	Moderate-high
Puget Oregonian (*Cryptomastix devia*)	Low-moderate
Poplar Oregonian (*Cryptomastix populi*)	Low
Mission Creek Oregonian (*Cryptomastix magnidentata*)	N/A
[unnamed Oregonian] (*Cryptomastix mullani hemphilli*)	N/A
Dalles Hesperian (*Vespericola depressa*)	Low-moderate

Taxonomic notes: The Polygyridae is a large and diverse family of roughly 294 described snail species in North America. The *Cryptomastix* species are medium to moderately large Pacific Northwest endemics; there are likely more *Cryptomastix* and other Polygyrids that will be described with genetic analysis, and some will deserve conservation attention. *C. magnidentata* (Pilsbry 1940) [=*Cryptomastix* (*Cryptomastix*) *n. sp. 2* ['Hells Canyon Oregonian' of Frest and Johannes 1995].

Biology and Life History

Dalles Hesperian
Photo: W. Leonard

Polygyrids are generally herbivorous and fungivorous snails; Dalles Hesperian feed by scraping algae, yeast, bacteria and diatoms from rock and woody surfaces; they may also consume green plant materials (Duncan 2009). All of the species addressed here are terrestrial, except the Washington Duskysnail (*Amnicola sp. no.2*), which is a freshwater snail. Washington Duskysnail is a detritivore and grazes along the stems and leaves of aquatic plants eating small organisms clinging to this material (Frest and Johannes, 1995). In most terrestrial gastropods, cross-fertilization appears to be the norm, but self-fertilization can occur in at least some species in the absence of potential mates. Pilsbry (1940) states of the family Polygyridae, "Their food is chiefly the mycelia of fungi." While it is suspected that mycophagy is the primary life style of these species, it appears that at least the young may be partially herbivorous on green plants during certain seasons.

Life history of the terrestrial Polygyrids may resemble that described for the Oregon Forestsnail (*Allogona townsendiana*). This species is most active during the wet spring months when mating occurs. Adults lay eggs in new or existing flask-shaped nesting holes, or sometimes in pre-existing depressions in soil, moss, and under coarse woody debris, or at the base of vegetation. Juvenile snails hatch approximately eight to nine weeks after oviposition, and disperse from the nest site within hours of hatching.

Oregon Forestsnails estivate deep within litter, under logs or the bark of coarse woody debris during dry summer months and become active again with fall rains. Once the first frosts occur, Oregon Forestsnails enter hibernation until the following spring. Adults likely reach reproductive maturity by two years and have a life span of at least five to eight years, though this may be an underestimate. Edworthy *et al.* (2012) reported that adults generally remained in a core area of less than 18 square yards. (The maximum daily dispersal was 15 feet and the maximum displacement over three years was 105 feet.

Columbia Oregonians consume herbaceous plants in captivity, and may also consume algae on wet surfaces and decaying remains of herbaceous plants.

Puget Oregonians hatch from eggs and live for more than one year. However, specific details on life span and reproduction for this species were not found. Like most terrestrial gastropods, *Cryptomastix* are hermaphroditic, having both male and female organs. Burke (1999) suggested that Puget Oregonian (*C. devia*) might aid in the dispersal of fungal spores, including mycorrhizal fungi that form tree-root associations which promote healthy tree growth.

Dalles Hesperians live approximately three to five years. Individuals may breed during their second season. Egg laying sites are thought to be in very moist or wet locations, such as in wet moss or under rocks or wood. They are present all year, but probably not active under snow in winter. Individuals are entirely terrestrial, but seek refugia sites where the humidity level is relatively high and temperature is constant, such as deep within cracks in mud, in rock talus or under permanently moist vegetation. May travel several hundred feet during a season, only to return to original refugia sites.

Distribution and Abundance

Dry Land Forestsnail: *Allogona* in the Pacific Northwest include three species; the very common *A. ptychophora* occurs from the Cascade Range in British Columbia into northern Oregon and east to the Continental Divide. A distinct subspecies, *A. ptychophora solida*, is confined to local populations in the Snake River Canyon, Asotin County, Washington, and eastward in Nez Perce and into Lewis Counties, Idaho. Distinct *A.p. solida* are locally common in Idaho, but appear rare west of the Snake River.

Washington Duskysnail: This species is currently known from only three lake sites: one in Ferry County, one in Okanogan County, and one in northwestern Montana. The Washington Duskysnail is declining due mainly to habitat degradation and destruction, both in terms of populations and numbers of individuals.

Columbia Oregonian: This species is known from 13 locations at the east end of the Columbia Gorge along both sides of the river from The Dalles to Rufus, Wasco and Sherman Counties in Oregon; this includes only four small sites in Klickitat County, Washington. Most locations are isolated from one another by the arid surrounding landscape. Originally also occurred in Skamania County, and in The Dalles, Oregon, but these sites were lost to by development. Specimens that may be this species suggest its range may extend north into Yakima County, and east along the Columbia and Snake Rivers and the Washington-Oregon border, in Umatilla and Wallowa Counties, Oregon, to Adams and Washington Counties, Idaho, but this requires confirmation.

Puget Oregonian: This species is found in the western Cascade Range and Puget Trough from southern Vancouver Island, B.C. through western Washington to the Oregon side of the Columbia Gorge. Records exist from Clark, Cowlitz, King, Lewis, Pierce, Skamania, and Thurston Counties, Washington. Kogut and Duncan (2005) noted 178 locations, but at most sites only one to three snails were found. Most sites are in Gifford Pinchot National Forest, where it is relatively common only in the Cowlitz and Cispus River drainages; elsewhere it is quite rare and local. Much of its former range is now urban or has been developed for agriculture; 10 of 42 records from prior to 1994 are from the metropolitan Seattle area. There is a single record from the eastern Cascades near Cle Elum. Formerly found in Hood River and Wasco Counties of Oregon, and in British Columbia (primarily Vancouver Island). In Oregon, this species is in severe decline; currently only a few sites in Multnomah County remain.

Poplar Oregonian: This species is found along the Snake River in Whitman and Asotin Counties, Washington, and in Cottonwood Canyon, Nez Perce County, Idaho.

Mission Creek Oregonian: This species is found in the Snake River Canyon, Grand Ronde Canyon, and Joseph Creek Wildlife Area in Asotin County, Joseph Canyon, Wallowa County, Oregon, and in Lewis and Nez Perce Counties, Idaho.

[unnamed Oregonian] (*C. mullani hemphilli*): A small disjunct population of this taxa occurs in Swakane Canyon in Chelan County. Also found in northern Idaho and Sanders and Missoula Counties, Montana.

Dalles Hesperian: This species survives at a few scattered, widely separate colonies in the Columbia Gorge: from Rufus, Oregon downstream to Vancouver, Washington. Historic sites are located in Wasco, Hood River and Sherman Counties in Oregon; and Clark, Skamania and Klickitat Counties in Washington. No specific information on abundance at these sites is documented.

Habitat

Dry Land Forestsnail: The Dry Land Forestsnail is found in talus and rocky riparian areas in the Snake River Canyon.

Washington Duskysnail: This is a freshwater species that occurs in kettle lakes among aquatic vegetation beds, but is absent from dense aquatic vegetation areas. The species is found on soft oxygen-rich substrate at a depth of approximately two to six feet.

Columbia Oregonian: This species occurs at seeps and spring-fed streams and in associated talus in the semi-arid eastern portion of the Columbia River Gorge. Inhabits margins of low to mid-elevation seeps, and spring-fed streams in an otherwise arid landscape. Typically found among moist talus, leaf litter and shrubs, or under logs and other debris.

Puget Oregonian: This species is thought to be a mature forest specialist and inhabits moist old-growth and late successional stage forests and riparian areas at low and middle elevations (below 600 feet). Mature to late successional moist forest and riparian zones, under logs, in leaf litter, around seeps and springs, and often associated with hardwood debris and leaf litter and/or talus. It is often found under or near bigleaf maple and may be under western swordferns growing under these trees, or on the underside of bigleaf maple logs. Canopy cover is generally high. Often found in old-growth western hemlock/swordfern plant associations with bigleaf maple and/or possibly other hardwood components well represented.

Poplar Oregonian: This species is found in talus and brushy draws in canyons in moderately xeric, rather open and dry situations, in talus on steep, cool (generally north or east facing) lower slopes in major river basins. Surrounding vegetation is sage scrub. Talus vegetation includes *Celtus*, *Artemesia*, *Prunus*, *Balsamorrhiza*, grasses, small limestone moss (*Seligeria* sp.) and bryophytes.

Mission Creek Oregonian: This species has been found in rocky, brushy draws and riparian areas.

[unnamed Oregonian] (*C. mullani hemphilli*): There is no habitat data available for this species.

Dalles Hesperian: This species is generally found in wet or very moist sites. In dry areas, it is associated with a permanent water source such as a spring or seep.

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Family Polygyridae: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
Columbia Oregonian					
1	Fish and wildlife habitat loss or degradation	Loss of perennial flow due to diversions	Taxonomic clarification for additional taxa; delineate occupied sites	Unknown	Both
2	Fish and wildlife habitat loss or degradation	Habitat loss to development	Delineate and protect sites	Unknown	Both
Dalles Hesperian					
1	Fish and wildlife habitat loss or degradation	Road building, disturbance of talus; habitat alteration that creates xeric conditions; need distribution data	Delineate and protect sites	Current insufficient	WDFW
2	Agriculture and aquaculture side effects	Unsustainable grazing of habitat	Install fencing to carefully manage or prohibit livestock access to occupied riparian areas	Current insufficient	Both
3	Resource information collection needs	Need distribution data	Inventory	Current insufficient	WDFW
Dry land Forestsnail					
1	Fish and wildlife habitat loss or degradation	Road building and maintenance	Delineate and protect sites	Current insufficient	WDFW
2	Resource information collection needs	Need distribution data	Identify sites	Current insufficient	WDFW
Mission Creek Oregonian					
1	Fish and wildlife habitat loss or degradation	Limestone quarrying	Develop management recommendations	Nothing current - new action needed	WDFW
2	Agriculture and aquaculture side effects	Unsustainable logging practices	Develop management recommendations	Nothing current - new action needed	WDFW
3	Agriculture and aquaculture side effects	Unsustainable grazing of riparian habitat	Install fencing to carefully manage or prohibit livestock access to occupied riparian areas	Nothing current - new action needed	Both
Poplar Oregonian					
1	Resource information collection needs	Status assessment	Status assessment	Current insufficient	Both

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
2	Fish and wildlife habitat loss or degradation	Mining of basalt talus	Management recommendations; tech assistance	Nothing current - new action needed	WDFW
3	Agriculture and aquaculture side effects	Livestock grazing practices that do not benefit the species	Outreach, coordinate with landowners to incorporate management recommendations to benefit the species	Nothing current - new action needed	Both
Puget Oregonian					
1	Resource information collection needs	Status assessment	Status assessment	Current insufficient	Both
2	Fish and wildlife habitat loss or degradation	Habitat loss to urbanization	Management recommendations; tech assistance	Nothing current - new action needed	WDFW
3	Agriculture and aquaculture side effects	Habitat loss to logging of old-growth; bigleaf maple	Management recommendations; tech assistance	Current insufficient	Both
Washington Duskysnail					
1	Fish and wildlife habitat loss or degradation	Pollution, siltation	Protect water quality	Current insufficient	External
2	Resource information collection needs	Taxonomic clarification	Formally describe species	Nothing current - new action needed	External
[unnamed Oregonian] (*Cryptomastix mullani hemphilli*)					
1	Resource information collection needs	Need taxonomic confirmation	Inventory; taxonomic clarification	Nothing current - new action needed	External

NOTE: Numbers are for reference only and do not reflect priority.

Family Vertiginidae

Conservation Status and Concern

These three very rare *Vertigo* species are small snails found in small isolated populations, perhaps remnants of a previously much wider range. These small populations, associated with old-growth and/or riparian hardwoods are very vulnerable to logging, road building, fires, or other disturbances.

Common Name (Scientific name)	Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend
Hoko Vertigo (*Nearctula new sp.* or *Vertigo new sp.*)	In review	None	No	G1	S1	Critical/unknown
Pacific Vertigo (*Vertigo andrusiana*)	None	None	No	GNR	S1?	Critical/ extirpated?
Idaho Vertigo (*Vertigo idahoensis*)	None	None	No	G1G2	SNR	Critical/unknown
	Climate vulnerability: Low-moderate					

Taxonomic note: Burke (2013) considers this group within the family Vertiginidae; earlier authorities placed the subfamily Vertiginninae in the family Pupillidae, and in the superfamily Pupilloidea, order Pulmonata, and class Mollusca (Duncan 2005). Frest and Johannes (1996b) placed the Hoko Vertigo into the *Vertigo californica* group. Sterki (1892) gave this group a subgeneric name, *Nearctula*, which was regarded as a synonym of the genus *Vertigo* by Pilsbry (1948). Recently *Nearctula* has been used by some authors as the valid genus for this species group. The Hoko Vertigo has not yet been formally named or described.

Biology and Life History

The Vertiginidae are minute (roughly .05 to 0.12 inch) terrestrial snails with ovoid-shaped shells. Land snails, including Vertiginid snails, are hermaphroditic and exchange gametes with conspecific individuals when conditions are favorable. At least some species seem to retain the fertilized eggs and give birth to small numbers of live young. The Hoko Vertigo is thought to be a short-lived species with a potential life span of less than two years. The distinctly arboreal lifestyle and mouthparts of this group of snails suggest that they feed on microorganisms growing on the surfaces of smooth-barked trees and shrubs or epiphytic lichens. In Pacific Northwest forests, Vertiginidae snails overwinter on tree limbs, so presumably they are not killed by freezing temperatures.

Vertigo columbiana
Photo: W. Leonard

Distribution and Abundance

Hoko Vertigo: Hoko Vertigo is known only from along the east side of the Hoko River in Clallam County in the northwestern part of the Olympic Peninsula. The tendency of these snails to have a patchy distribution may make it difficult to make estimates of population size and population trends. Surveys of roughly 300 acres in Olympic National Forest did not find any new locations. Random grid surveys across the Northwest Forest Plan area in Oregon and Washington did not locate this species in any of 498 plots searched. However, a specimen that may prove to be this species was collected in the Salem BLM district of Oregon. This species is under review by the USFWS for listing under the ESA.

Pacific Vertigo: This species appears to have once been widely distributed in the Pacific Northwest, with a historical range including well-separated areas of the Cascade and Klamath provinces. It is now apparently very rare, with no confirmed sightings in the Oregon/Washington region in recent years. There are historical records from the San Bernardino Mountains of California north through western Oregon and southwest Washington to Vancouver Island, British Columbia. In Washington, records are in the Puget Trough and Olympic Peninsula (Grays Harbor, Thurston, and King Counties). In Oregon, the species occurred west of the Cascade Mountains, with records from Clackamas, Douglas and Klamath Counties. To date, most known records are from before 1950, with the exception of one 1979 record from Thurston County, Washington, and one 1999 record from Fremont-Winema National Forest, Klamath County, Oregon (Jordan 2013).

Idaho Vertigo: Burke (2013) collected this species along a creek in Stevens County, Washington. Pilsbry (1948) found it along a creek east and northeast of the old town, Meadows, Adams County, Idaho. The type locality is the only known Idaho site, but this population has not been relocated. Searches during 1988, 1993, and 1994 within the lower Salmon River, Little Salmon River, and Payette River drainages in Idaho have also failed to find this species.

Habitat

The typical habitat for Vertigo snails ranges from moist riparian to relatively dry forests dominated by cottonwood, alder, Douglas-fir, spruce, or hemlock, depending on the species.

Hoko Vertigo: The Hoko Vertigo seems to be an old-growth riparian associate. The two known locations are at the bases of wooded slopes near streams at low elevations of between roughly 40 and 300 feet; it is unknown if the species occurs at higher elevations. The habitat seems to be characterized by old trees, riparian hardwoods, and mesic conditions. This species is arboreal and has been found on trunks and lower limbs of deciduous trees, mainly alders. They are most easily detected on the undersides of limbs and leaning trunks of young alders that have relatively smooth bark. One of the two known sites is at the base of a steep northwest-facing slope with seeps and consists of second-growth Douglas-fir forest with a sizable component of bigleaf maple. This site is near a stream; understory vegetation includes liverworts, large swordfern, and maidenhair fern. The other site is at the foot of a slope next to the Hoko River and is characterized by the presence of old hardwood trees, mostly alder.

Pacific Vertigo: This species occurred in forested sites at lower elevations and may be found on trunks and lower branches of deciduous trees and shrubs, as well as among the litter beneath them. Pilsbry (1948) wrote that “some thousands of specimens were taken…about clumps of bushes in a meadow" in Oswego, Clackamas County, Oregon. A 1979 Thurston County record notes “maple, salal” as the habitat. A 1999 record from Klamath County, Oregon (Fremont-Winema National Forest) lists the habitat as a drainage through a small open meadow with an overstory of ponderosa pine and western juniper.

Idaho Vertigo: This species is a riparian associate, but there is little other information. Habitat characteristics are described from only the type locality. At this site, the Idaho Vertigo inhabits a mid-elevation grass and sedge meadow with springs, seeps, bogs, and fens.

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Family Vertiginidae: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
Hoko Vertigo					
1	Agriculture and aquaculture side effects	Activities that result in drying of habitat (such as logging); need formal species description	Protect sites	Current insufficient	Both
2	Resource information collection needs	Need formal species description	Taxonomy; describe species; protect sites	Current insufficient	External
Idaho Vertigo					
1	Resource information collection needs	Need distribution data	Inventory; status assessment	Current insufficient	Both
Pacific Vertigo					
1	Resource information collection needs	Need distribution data; may be extirpated	Inventory/status information	Current insufficient	Both

NOTE: Numbers are for reference only and do not reflect priority.

OTHER TERRESTRIAL SNAILS

Conservation Status and Concern

These terrestrial snails are very rare and have distributions that include small isolated populations, perhaps remnants of previously much wider ranges. These small isolated populations, often associated with old-growth and/or riparian hardwoods and are very vulnerable to logging, road building, fires, or other disturbances.

Common Name (Scientific name)	Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend
Oregon Megomphix (*Megomphix hemphilli*)	None	None	No	G3	S1	Low/unknown
Dalles Sideband (*Monadenia fidelis minor*)	In review	Candidate	Yes	G4G5T2	S1	Low/unknown
Crowned Tightcoil (*Pristiloma pilsbryi*)	None	None	No	G1	S1	Low/unknown
Nimapuna Tigersnail (*Anguispira nimapuna new spp*.)	None	None	No	G1	SNR	Critical/ unknown

CLIMATE VULNERABILITY RANKING	
Common Name (Scientific name)	Ranking
Oregon Megomphix (*Megomphix hemphilli*)	Low-moderate
Dalles Sideband (*Monadenia fidelis minor*)	Low-moderate
Crowned Tightcoil (*Pristiloma pilsbryi*)	Low-moderate
Nimapuna Tigersnail (*Anguispira nimapuna new spp*.)	N/A

Taxonomic note: Oregon Megomphix is in the family Megophicidae; Dalles Sideband is in the Bradybaenidae; Crowned Tightcoil is in the Pristilomatidae; Nimapuna Tigersnail is in the Discidae. '*Anguispira nimapuna* new spp' appears to be an undescribed subspecies (T. Burke, pers. comm.); they are distinctly like *A. nimapuna* from Idaho, but are smaller, with thinner shells and with weaker rib sculpturing.

Biology and Life History

Land snails are hermaphroditic and exchange gametes with other conspecific individuals when conditions are favorable, typically in the spring, and then both will lay eggs in damp subsurface situations where the eggs will be relatively safe from predators and desiccation. Land snails do not tend their eggs or young. There is no larval stage and newborn snails look like miniature adults (the innermost part of the shell develops within the egg).
Snails need moisture, so where the habitat dries out, they will estivate in the summer, become active with fall rains,

Oregon Megomphix
Photo: W. Leonard

and hibernate when the season turns cold. Land snails eat plants (living or dead), fungi, fruit, microorganisms, litter, wood, and dead animals. Of these species, more is known about Oregon Megomphix and the Dalles Sideband. The Oregon Megomphix seems to be more secretive and photophobic than other Northwest land snails, as no live animals and very few of their shells have been found out in the open; all have been found under the cover of leaf mold or within soft soil or in spaces within rock heaps. Loose soil may be necessary for egg-laying by sideband snails, which lay several dozen eggs; they are likely to live more than six years, and probably mature in two years. During the moist spring and fall seasons, Dalles Sidebands may be found in the open, away from refugia. Daily refugia used during moist seasons can be down wood, rock or accumulations of litter. During the summer, snails are found deep in talus accumulations which are adjacent to springs or streams and which serve as refuge sites from desiccation and protection from predators while the snails are immobile. These deep rock refugia also provide the important, environmentally stable sites needed to survive wildfire events and cold winter conditions. Mollusks which inhabit talus habitats also utilize the surrounding forest areas during moist, cool conditions, ranging out from the refugia provided by the rocks to forage in the adjacent forest floor litter.

Distribution and Abundance

Oregon Megomphix: This species is known from Olympia southward in foothills of the Cascade and Coast Ranges in conifer/hardwood forests up to 3000 feet in elevation, south through the Willamette Valley, Cascade Range foothills, and Coast Range of Oregon. For Washington there are 12 records from Thurston, Lewis, and Cowlitz Counties based on 45 specimens (many collected 30 to 120 years ago) that provide seven mappable locations, which are all at low elevations (below 500 feet) in the southwestern part of the state. It is more widespread in Oregon, known from the Siuslaw, Umpqua, and Willamette National Forests and is suspected to occur in the Mt. Hood, Rogue River, and Siskiyou National Forests, and the Columbia River Gorge National Scenic Area.

Dalles Sideband: This species is known from the Columbia Gorge from Hood River east to the vicinity of The Dalles on both sides of the Columbia River and in upland sites in the lower Deschutes River watershed within Mt. Hood National Forest in Wasco County, Oregon. The species may have occurred historically in the central and part of the eastern Columbia Gorge and south up the Deschutes River Valley as far as 50 miles from the confluence. A total of 98 sites are known, but most sites are in Oregon, and only a few individuals have been found at most sites. Known sites are widely scattered across the species' range and separated by non-habitat. The distribution of stable rock refugia sites across the landscape may determine or help to explain the distribution of the species in areas with short fire-return intervals.

Crowned Tightcoil: This species is known from Pacific County, Washington and the Northern Coast Range of Oregon; there are also historical records from Portland. Stone (2009) states it has also been found in Clallam County, Washington, and is suspected to occur in Grays Harbor, Wahkiakum, Cowlitz and Clark Counties, Washington and Multnomah, Clatsop and Columbia Counties, Oregon.

Nimapuna Tigersnail: This yet-to-be described subspecies occurs at two locations on ridges on opposite sides of Lake Chelan, Chelan County, Washington (Burke 2013). Outside of Washington, this species is known from less than 10 localities in the Clearwater, Lochsa, and Selway Rivers' drainages in Idaho County, Idaho, and Wallowa County, Oregon (Hendricks et al. 2006, Burke 2013).

Habitat

Oregon Megomphix: Habitat is within moist conifer/hardwood forests up to 3000 feet in elevation in hardwood leaf litter and decaying non-coniferous plant matter under bigleaf maple trees, or beaked hazelnut (*Corylus cornuta*) bushes, and swordferns, often near rotten logs or stumps. A bigleaf maple component in the tree canopy and an abundance of swordfern on forested slopes and terraces seem characteristic. Appears to be primarily fossorial, often found on soil under leaf litter or in rodent burrows. The presence of rotten logs seems to be important to local survival. Unusually large or multiple-stemmed bigleaf maples, or clumps of bigleaf maples, seem to provide the most favorable habitat.

Dalles Sideband: The species has been found in moist talus habitat (especially around seeps and springs), and in forested areas in upland sites near, but outside of, riparian corridors. In some forested sites, the species has been found associated with down wood where no rock substrates occur. Down wood may provide temporary refugia used during dispersal in the wet season, while rock substrates provide more stable refugia used for estivation during summer and winter and during fire events.

Crowned Tightcoil*:* This species has been collected in moist leaf and woody debris litter in low elevation forested areas under the dense thickets of salal (*Gaultheria shallon*) near the coastal beaches, and in riparian areas under red alder and swordfern. Stone (2009) characterizes it as associated with riparian and old-growth habitat, though it has been collected in the headwater riparian areas of managed second-growth western hemlock forests. Typically associated with abundant, persistent moisture.

Nimapuna Tigersnail: In Idaho this species has been found between 1500-2550 feet in elevation at sites with an overstory that included western red-cedar and grand fir, with some alder, paper birch, Douglas-fir and/or ponderosa pine; often under wood or on bryophyte mats among dense ferns.

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OTHER TERRESTRIAL SNAILS: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
Crowned Tightcoil					
1	Fish and wildlife habitat loss or degradation	Habitat loss to development	Technical assistance to regulatory agencies	Current insufficient	WDFW
2	Agriculture and aquaculture side effects	Logging of mature timber	Develop management recommendations	Current insufficient	WDFW
3	Resource information collection needs	Need to delineate distribution	Inventory	Current insufficient	Both
Dalles Sideband					
1	Fish and wildlife habitat loss or degradation	Road building; fires; habitat alteration that creates xeric conditions	Develop management recommendations	Current insufficient	WDFW
Nimapuna Tigersnail					
1	Resource information collection needs	Lack of data; need distribution data.	Describe and protect sites	Nothing current - new action needed	WDFW
2	Resource information collection needs	Possible new subspecies; need taxonomic clarification	Clarify taxonomy	Nothing current - new action needed	External
Oregon Megomphix					
1	Overharvesting of biological resources	Cutting of bigleaf maples for burls; loss of rotten logs	Increased protection of bigleaf maples by enforcement, outreach, etc.	Current insufficient	External
2	Resource information collection needs	Clarify distribution, status	Status assessment	Nothing current - new action needed	Both

NOTE: Numbers are for reference only and do not reflect priority.

Families: Lymnaeidae and Hydrobiidae

Conservation Status and Concern

These species require clear, cold, well-oxygenated waters, and are threatened by pollution and siltation. North America once had approximately 700 species of native freshwater snails from 16 families. Currently, 67 species (10 percent) are considered likely extinct, 278 (40 percent) endangered, 102 (15 percent), threatened, 73 (10 percent) vulnerable, and 26 (4 percent) have uncertain taxonomic status.

Common Name (Scientific name)	Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend
Shortface Lanx *or* Giant Columbia River Limpet (*Fisherola nuttalli*)	None	Candidate	Yes	G2	S2	Uncommon/ declining
Masked Duskysnail (*Lyogyrus sp. 2*)	None	None	No	G1G2	S1	Critical/declining
Olympia Pebblesnail (*Fluminicola virens*)	None	None	No	G2	S2	Low/unknown
Salmon River Pebblesnail (*Fluminicola gustafsoni*)	None	None	No	GNR	SNR	Low/unknown
Ashy Pebblesnail (*Fluminicola fuscus*)	None	Candidate	Yes	G2	S2	Uncommon/ declining

CLIMATE VULNERABILITY RANKING	
Common Name (Scientific name)	Ranking
Shortface Lanx *or* Giant Columbia River Limpet (*Fisherola nuttalli*)	Moderate
Masked Duskysnail (*Lyogyrus sp. 2*)	Low-moderate
Olympia Pebblesnail (*Fluminicola virens*)	Low-moderate
Salmon River Pebblesnail (*Fluminicola gustafsoni*)	N/A
Ashy Pebblesnail (*Fluminicola fuscus*)	Moderate

Taxonomic notes: The Shortface Lanx (*Fisherola nuttalli*) is in the family Lymnaeidae (it is not a limpet); Masked Duskysnail (*Lyogyrus sp. 2*) is an undescribed species in the family Hydrobiidae. The genus *Fluminicola* was formerly considered to be in the family Hydrobiidae, but more recent classification system based on genetics treats Lithoglyphidae at the family level, instead of as a subfamily (Lithoglyphinae) in the Hydrobiidae family (Jordan 2013). Hershler and Liu (2012) indicate that the genus *Fluminicola* includes two separate lineages and is in need of revision. The Salmon River Pebblesnail (*F. gustafsoni*) is a recently described species, closely related to *F. virens*.

Ashy Pebblesnail
Photo: WDFW

Biology and Life History

For these aquatic snails, limiting factors may include hardness, acidity, dissolved oxygen, salinity, high temperature, and food availability as associated with depth. Snails are uncommon in habitats with surface acidity greater than pH 5. Dissolved oxygen limits diversity, so severely polluted waters (oxygen consumed by algae blooms) are often devoid of freshwater snails excepting pollution-tolerant species. Most species live in the shallows, (depths less than 10 feet) where food abundance is greatest. As a result, drastic water fluctuations (draw-downs) may cause declines in snail populations.

Shortface Lanx: This is a small pulmonate (lunged) snail; it feeds by scraping algae and diatoms from rock surfaces in streams. May occasionally feed on other plant surfaces. *Fisherola* are hermaphrodites but do not appear to be self-fertilized, thus mating occurs between two individuals. Eggs are laid from spring to autumn in gelatinous capsules attached to plants, stones, or other objects. They lack a free-swimming larval stage, and hatchlings are morphologically similar to adults, except that they lack a functional reproductive system. Young snails appear to grow rapidly and require only a few months to reach full size. Individual *F. nuttalli* probably live for only one year, as this species breeds once and dies afterwards (semelparous breeding). Individuals are present year-round in the streams they inhabit, but are inactive during the winter.

Masked Duskysnail*:* This species, like all Hydrobiid snails, has gills that make them dependent upon dissolved oxygen in the water. This species feeds on the algal and microbial film on aquatic plants, and likely on detritus. Individuals overwinter as adults and do not disperse widely, so populations remain very localized in their distribution. Information is sparse, but reproductive biology is probably similar to other Hydrobiid species. Hydrobiids typically are dioecious (i.e., have separate sexes) and semelparous (i.e., breed only once in their life time and then die), and individuals have a life span of one year, with 90 percent or more of the population turning over annually. Surviving individuals are generally those that do not breed during their first year. Eggs are laid in the spring and hatch in approximately two to four weeks. Sexual maturity is reached by late summer after a few months of growth.

Pebblesnails: Pebblesnails feed by scraping bacteria, diatoms and other perilithic organisms from rock surfaces, and may occasionally feed on aquatic plant surfaces. This species is present all year, but not active in winter. Having no lungs or gills, snails in this genus respire through the mantle cavity, and have low tolerance for hypoxia and anoxia. The *Fluminicola* genus exhibits separate sexes with both male and female individuals. Reproduction is by copulation and cross-fertilization, and these species are believed to be semelparous (reproducing only once in a lifetime). Eggs are laid from spring to autumn in gelatinous capsules attached to plants, stones, or other objects. The individual life span of these species is thought to be approximately one to two years, and population turnover is probably greater than 90 percent. Often, species in this genus appear to be community dominants, comprising most of the invertebrate biomass.

Distribution and Abundance

Shortface Lanx: This species was historically present throughout much of the Columbia River drainage in Washington, Montana, Oregon, Idaho, and British Columbia, but most populations were extirpated due to habitat loss resulting from dams, impoundments, water removal, and pollution. This species is now presumed extirpated in Montana and possibly in British Columbia. Currently in Washington, large populations of *F. nuttalli* persist in the Okanogan River and the Hanford Reach of the Columbia River; small populations are found in the Methow and Grand Ronde rivers. The species also occurs in the lower Deschutes River in Oregon, and the Snake River in Oregon and Idaho. In Idaho, it occurs in the Middle and Upper Snake River reaches from Elmore County, upstream to at least Bingham County. Populations also occur in the Salmon River and Hells Canyon of the Snake River including parts of Nez Perce and Idaho Counties. Additional small populations are found in Oregon in the Grande Ronde, John Day, and Imnaha Rivers, and the lower Columbia River near Bonneville Dam.

Masked Duskysnail: The Masked Duskysnail is currently known from three or four sites in two kettle lakes: Curlew Lake in Ferry County, Washington, and Fish Lake, Chelan County, Washington.

Olympia Pebblesnail: The Olympia Pebblesnail is known only from Oregon and Washington. In Washington, it is known from about 12 locations, including Cowlitz, Grays Harbor, Pacific, San Juan, Skamania and Thurston Counties in Washington. In Oregon, it is limited in distribution to the lower Columbia River below Portland, the upper Deschutes River, the Umpqua River, the Willamette River from Corvallis to its mouth, and large tributary streams of the Willamette River including the Tualatin and Clackamas Rivers.

Salmon River Pebblesnail: This species is known only from the Salmon, Clearwater and lower Snake Rivers. In Washington it is only recorded from Asotin County.

Ashy Pebblesnail: This species has been extirpated from much of its historic range. It was historically widespread, with populations scattered throughout Washington in the lower Snake River, lower to middle Columbia River, and large tributaries of these rivers including the Methow, Willamette, Wenatchee, Deschutes, Okanogan, Grande Ronde, and Spokane Rivers (Asotin, Benton, Cowlitz, Chelan, Clark, Franklin, Klickitat, Okanogan, Skamania, Spokane, and Walla Walla Counties). Targeted surveys were conducted at over 500 sites in more than 30 streams in the Columbia Basin (Oregon, Washington, Idaho); this species was absent from nearly all sites (including some historic sites), and detected at just five streams. In Washington, it has been detected relatively recently (1990 or later) in the Okanogan, Grande Ronde and Methow Rivers; Hanford Reach of the Columbia River; and a limited portion of the Snake River.

Habitat

Shortface Lanx: Shortface lanx are found in unpolluted, cold, well-oxygenated perennial streams and rivers, generally 100 to 325 feet wide, with a cobble-boulder substrate. Within such streams it is found primarily on diatom-covered rocks at the edges of rapids or immediately downstream from rapids in areas that have suitable substrate. Shortface Lanx have not been found in areas with silt or mud substrates, extreme seasonal variations in water level, an abundance of aquatic plants or algae, bedrock substrate, or where dredging or mining occurs.

Masked Duskysnail: This species is a kettle lake inhabitant and riparian associate. It lives in lentic ecosystems on oxygenated mud substrates with aquatic plants.

Pebblesnails: This genus is fairly intolerant of impounded waters and soft substrates as well as nutrient-enhanced or lacustrine (lake) habitats. These species are usually found in clear, cold streams with high dissolved oxygen content. They are generally found on hard rocky surfaces where they graze on algae and detritus. They occur under rocks and vegetation in the slow to rapid currents of streams. It is common at the edges of rapids or immediately downstream from whitewater areas, and becomes much less common or absent in major rapids. In the absence of rapids or whitewater areas, this species is restricted to habitat with sufficient flow, oxygenation, and stable substrate.

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Families: Lymnaeidae and Hydrobiidae

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
Ashy Pebblesnail					
1	Fish and wildlife habitat loss or degradation	Water pollution, siltation	Protect water quality	Current Insufficient	Both
Masked Duskysnail					
1	Fish and wildlife habitat loss or degradation	Pollution	Protect sites	Nothing current - new action needed	Both
2	Resource information collection needs	Formally describe species	Taxonomy; describe species	Nothing current - new action needed	External
Olympia Pebblesnail					
1	Fish and wildlife habitat loss or degradation	Pollution, siltation	Improve water quality of occupied streams	Current insufficient	Both
Salmon River Pebblesnail					
1	Fish and wildlife habitat loss or degradation	Pollution, siltation	Improve water quality of occupied streams	Current insufficient	External
Shortface Lanx					
1	Fish and wildlife habitat loss or degradation	Pollution and siltation	Protection of water quality	Current insufficient	WDFW
2	Agriculture and aquaculture side effects	Pollution and siltation	Develop management recommendations	Current insufficient	WDFW

NOTE: Numbers are for reference only and do not reflect priority.

Family Pleuroceridae (Genus *Juga*): FRESHWATER AQUATIC SNAILS

Conservation Status and Concern

These species require cold, clear, well-oxygenated water; they are sensitive to pollution, and intolerant of warm waters, low dissolved oxygen, or major seasonal fluctuations. Destruction of springs by grazing, logging, and diversions (e.g. for water supply, fish hatcheries) has already caused extensive extinction of *Juga* species throughout western North America.

Common Name (Scientific name)	Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend
Barren Juga (*Juga hemphilli hemphilli*)	None	None	No	G2T1	S1	Low/unknown
Dalles Juga (*Juga hemphilli dallesensis*)	None	None	No	G2T1	S1	Low/unknown
Brown Juga (*Juga sp. 3*)	None	None	No	G1	S1	Low/unknown
Three-band Juga (*Juga sp. 7*)	None	None	No	G1	S1	Low/unknown
One-band Juga (*Juga sp. 8*)	None	None	No	G2G3	SNR	Low/unknown
	Climate vulnerability: Moderate-high					

Taxonomic notes: The genus *Juga* and *Oreobasis* are synonymous. Three-Band Juga (*Juga* sp. 7) listed as Juga (*Juga* n. sp. 2) and One-band Juga (*Juga sp. 8)* listed as *Juga* n. sp. 1 in Frest and Johannes (1995: 178). The taxonomy of the Pleuroceridae, like most freshwater gastropods, has been based largely on shell morphology, and the tremendous variation makes the current taxonomy problematic and species identification difficult. Current work using reproductive anatomy and DNA to help resolve some of the taxonomic problems will likely result in changes in taxonomy in the future. Lee et al. (2006) analyzed DNA and suggested that *J. hemphilli* is a disjunct lineage from eastern North America, and should be designated *Elimia hemphilli*, but O'Foighil et al. (2009) reported that the Lee et al. (2006) paper was based on mislabeled voucher specimens, and confirmed that *J. hemphilli* belongs in *Juga* based on both DNA and anatomical evidence.

Biology and Life History

Juga species are freshwater aquatic snails with tall conical shells, native to the streams and springs of the Pacific Northwest and the Great Basin. *Juga* snails are characterized as rasper-grazers, feeding on both algae and detritus on rock surfaces and deciduous leaf litter. They exhibit seasonal migrations both upstream and downstream. The egg masses of *Juga* are most often found in loose (non-cemented) but stable cobble substrate, with free and fairly vigorous flow through at least the upper substrate layers. Egg masses are located under rocks in the spring, and eggs hatch in one month. *Juga* species live from five to seven years, reaching sexual maturity in three years, and can continue to grow.

Genus *Juga*
Photo: nwnature.net

Distribution and Abundance

Where found, *Juga* can comprise over 90 percent of the invertebrate biomass in some streams. These five species seem to be restricted in distribution in Washington to the Columbia River Gorge, which historically provided abundant springs for habitat. Frest and Johannes (1995) systematically collected throughout much of the Gorge from 1987-1992, so that substantial additions to the range or an increase in the number of sites is highly unlikely.

Barren Juga: Barren Juga are known from a few populations on the west end of the Columbia Gorge in Washington and Oregon (mostly urbanized areas in Clark and Skamania Counties, Washington and Multnomah County, Oregon). Dillon (1989) lists occurrences from Oak Creek west of Corvallis, Benton County, Oregon.

Dalles Juga: The Dalles Juga has been found in Mill Creek and the central and eastern Columbia River Gorge from Hood River to the Dalles, in Hood River and Wasco Counties, Oregon and Skamania County, Washington. Lee et al. (2006) determined that material collected in 1883 by Whiteaves at the headwaters of the Columbia River in British Columbia and described as *Goniobasis columbiensis* is, in fact, this species.

Brown Juga: The Brown Juga is rare, found only in a few of the central and eastern Columbia Gorge tributaries, Skamania and Klickitat Counties, Washington, and in Multnomah and Hood River Counties, Oregon (Frest and Johannes 1995).

Three-band Juga: Three-band Juga are known from scattered sites, mostly in the eastern Columbia Gorge: Skamania and Klickitat Counties., WA, and Hood River, Wasco, Sherman, and Gilliam Counties, Oregon.

One-band Juga: One-band Jugas are known from a few of the central and eastern Columbia Gorge tributaries in Skamania and Klickitat Counties, Washington. Substantive range extensions are unlikely as most of the Columbia Gorge streams, as well as tributaries of the Klickitat and White Salmon rivers in recent years were surveyed.

Habitat

Barren Juga: The Barren Juga is found at low elevation large springs and small to medium streams with a level bottom and a stable gravel substrate and fast-flowing, unpolluted, highly oxygenated cold water. These typically lack aquatic macrophytes and have little epiphytic algae.

Dalles Juga: This species is found in low elevation large springs and small to medium streams with a stable gravel substrate and fast-flowing, unpolluted, highly oxygenated cold water. Relatively few macrophytes or epiphytic algal taxa are present.

Brown Juga: This species is found in low to medium elevation small spring-fed streams and springs, with cold, fast-flowing, well oxygenated water and gravel substrate. It is most frequently found in very small and shallow but perennial spring-fed streams and springs.

Three-band Juga: This species occurs in shallow, slow flowing springs and permanent seeps, sometimes associated with talus. Most often, these are covered by dense brush; the substrate ranges from bare rock faces to mud and sand. Rarely, this species occurs in smaller spring-fed streams.

One-band Juga: This species occurs in low to mid-elevation spring-fed streams and large springs with, cold, fast flowing, highly oxygenated water and a level bottom; if in streams, only in low-gradient streams, generally spring-fed.

References

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USFWS. 2011. Endangered and Threatened Wildlife and Plants: 90-day finding on a petition to list 29 mollusk species as threatened or endangered with critical habitat: proposed rule. Federal Register 76 (No. 193, October 5, 2011): 61826-61853

Family Pleuroceridae: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
Barren Juga					
1	Fish and wildlife habitat loss or degradation	Water diversions; habitat destruction; pollution	Protect water quality	Current insufficient	Both
2	Resource information collection needs	Taxonomic uncertainty may mean one or more taxa are in greater decline;	Taxonomic clarification	Current insufficient	External
Brown Juga					
1	Fish and wildlife habitat loss or degradation	Water diversions; habitat loss to development	Protect small spring-fed streams	Current insufficient	WDFW
2	Resource information collection needs	Taxonomic uncertainty may mean one or more taxa are in greater decline;	Taxonomic clarification	Current insufficient	External
Dalles Juga					
1	Fish and wildlife habitat loss or degradation	Water diversions; habitat loss to development	Taxonomic clarification	Nothing current - new action needed	Both
2	Resource information collection needs	Taxonomic uncertainty may mean one or more taxa are in greater decline;	Taxonomic clarification	Current insufficient	External
One-band Juga					
1	Fish and wildlife habitat loss or degradation	Water diversions; habitat loss to development	Taxonomic clarification	Unknown	Both

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
2	Resource information collection needs	Taxonomic uncertainty may mean one or more taxa are in greater decline;	Formal species description, taxonomic clarification	Nothing current - new action needed	External
Three-band Juga					
1	Resource information collection Needs	Need formal species description and status assessment	Formal species description, and status assessment	Nothing current - new action needed	Both
2	Fish and wildlife habitat loss or degradation	Water diversions; habitat loss to development	Management recommendations; identification and protection of sites;	Nothing current - new action needed	Both
3	Agriculture and aquaculture side effects	Intensive livestock use may trample the species or reduce riparian vegetation	Install fencing to carefully manage or prohibit livestock access to occupied riparian areas	Current insufficient	Both

NOTE: Numbers are for reference only and do not reflect priority.

SLUGS

TAILDROPPER SLUGS

Conservation Status and Concern

These endemic taildropper slugs are of concern due to their rarity. The Spotted Taildropper is only found in part of one county, and the rarity of both species suggest they have specific habitat needs that make them sensitive to land use activities, such as logging and loss of coarse woody debris.

Common Name (Scientific name)	Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend
Bluegray Taildropper (*Prophysaon coeruleum*)	None	Candidate	Yes	G3G4	S1	Low/declining
Spotted Taildropper (*Prophysaon vanattae pardalis*)	None	None	No	GNR	SNR	Critical/ unknown
	Climate vulnerability: Low-moderate					

Taxonomic note: *P.v. pardalis* has not been formally described as a subspecies; some specimens collected in northwestern Oregon assigned to this taxa appear to be a color variation of *P. andersoni*. Molecular analysis compared the genetic similarities of specimens identified as *P. coeruleum* from locations in western Oregon, Washington, California and Idaho. The results indicate that the species is not monophyletic in regards to color (i.e., body color is not related to genetic similarity), and there is a divergence in genetic similarity that occurs in southwestern Oregon populations which has resulted in several "clades" or variants in that region. None of these clades as yet have been officially named or described as subspecies or separate species.

Biology and Life History

Bluegray Taildropper
Photo: J.S. Applegarth

Like most terrestrial gastropods, taildroppers are hermaphroditic, having both male and female organs. Although not confirmed specifically for *P. coeruleum*, self-fertilization has been demonstrated in some species of gastropods, but cross-fertilization is the norm. Slugs are generally oviparous (egg-laying). Eggs of *Prophysaon* slugs are laid in clusters in cool damp spots including under logs or pieces of wood on the shaded forest floor. Slugs are preyed upon by a variety of vertebrates and other invertebrates. Tail-dropping is a means to escape some predators. Fungi made up most (90 percent) of the identifiable food ingested by *P. coeruleum*; this included a variety of mycorrhizal fungi and the species may be an agent of spore dispersal for these fungi, which are beneficial symbionts of many plants. Other food items include plant material and lichens; plant material is more commonly consumed in spring than in fall. There is no specific information available about the life history of the Spotted Taildropper.

Distribution and Abundance

Bluegray Taildropper: This species occurs in a few isolated populations and is a rare Pacific Northwest endemic closely associated with coniferous forest stands and conifer debris. In Washington, scattered sites are documented within the Puget Trough; extant populations occur in Lewis and Cowlitz Counties. The entire species range encompasses the Oregon Coast Range, Oregon and Washington Cascades, Puget Trough, Klamath Mountains of southwestern Oregon and northern California, western Idaho, and southern Vancouver Island, British Columbia. Although somewhat widespread and abundant in southwestern Oregon, it is rare and likely declining elsewhere in its range (including the rest of Oregon, and in California, Washington, Idaho, and British Columbia) with populations scattered and disjunct.

Spotted Taildropper: A quite rare subspecies from a very limited range in Pacific County, Washington. It is a rare spotted form of the Scarletback Taildropper, a common slug of western Washington and western Oregon forests. May or may not also occur in northwestern Oregon.

Habitat

Bluegray Taildropper: This species inhabits moist, coniferous or mixed-wood forests of varying age classes and is associated with moist forest floor conditions and abundant coarse woody debris, particularly of bigleaf maple. All records from British Columbia are from within the Coastal Douglas-fir biogeoclimatic zone, while in Washington, it is often associated with older forests and required microhabitat features, including abundant coarse woody debris or other cover, a deep forest litter layer and shaded, moist forest floor conditions.

Spotted Taildropper: Little habitat information is available for this subspecies; they have been found in snags, stumps, coarse woody debris, and large swordferns.

References

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Taildropper Slugs: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
Bluegray Taildropper					
1	Agriculture and aquaculture side effects	Logging of mature forest sites, loss of coarse woody debris	Identify and protect sites	Nothing current - new action needed	External
Spotted Taildropper					
1	Resource information collection needs	Lack of data on current status and distribution	Determine distribution, population status	Current insufficient	Both

NOTE: Numbers are for reference only and do not reflect priority.

FRESHWATER BIVALVES

Families Unionidae and Margaritiferidae: FRESHWATER MUSSELS

Conservation Status and Concern

Freshwater mussels have been greatly affected by dams and annual water drawdowns, as well as degraded water quality resulting from development and agriculture. Many historical sites no longer support mussels, and many local populations no longer successfully reproduce.

Common Name (Scientific name)	Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend
California Floater (*Anodonta californiensis*)	None	Candidate	Yes	G3Q	S2	Low/declining
Winged Floater (*Anodonta nuttaliana*)	None	None	No	G4Q	S1	Low/declining
Western Ridged Mussel (*Gonidea angulata*)	None	None	No	G3	S2S3	Uncommon/ declining
Western Pearlshell (*Margaritifera falcata*)	None	None	No	G4G5	S3S4	Uncommon/ declining
	Climate vulnerability: Moderate					

Taxonomic notes: Recent genetic research suggests that the California and Winged Floaters belong to a single clade, and that this clade exhibits basin-specific substructuring and may contain at least six distinct groups. However, before new species or genus level designations are made, the taxonomy for the entire Unionidae family needs to be resolved. The Western Ridged Mussel is the only species in the genus Gonidea.

Biology and Life History


Western Pearlshell
Photo: WDFW

Freshwater mussels are filter feeders that consume phytoplankton and zooplankton suspended in the water. Freshwater mussels have separate sexes, although hermaphrodites (individuals with male and female traits that are capable of self-fertilization) have been documented for some North American species, including the Western Pearlshell. Freshwater mussels have a complex life cycle. During breeding, males release sperm into the water and females filter it from the water for fertilization to occur. Embryos develop into larvae called glochidia, which are released into the water and must encounter and attach to a fin or gill filaments of host fish. Glochidia form a cyst around themselves and remain on a host for several weeks. They subsequently release from the host fish and sink to the bottom, burrow in the sediment and remain buried until they mature. During their lives, mussels may move less than a few yards from the spot where they first landed after dropping from their host fish. Because freshwater mussels are not able to move far on their own, their association with fish allows them to colonize new areas, or repopulate areas from which they have been extirpated. Freshwater mussels that live in dense beds, including Western Ridged Mussel and Western Pearlshells, provide an important water purification service; they can filter suspended solids, nutrients and contaminants from the water column and collectively improve water quality by reducing turbidity and controlling nutrient levels.

California Floater/Winged Floater: Floater species grow quickly, reach sexual maturity in four to five years, and probably have a maximum life span of about 15 years. Host fish are unknown, but may include Chiselmouth (*Acrocheilus alutaccus*) and Northern Pikeminnow (*Ptychocheilus oregonensis*). Like other freshwater mussels, California and Winged Floaters rely on host fishes to reproduce and disperse.

Western Ridged Mussel: The Western Ridged Mussel is a relatively slow growing and long-lived species perhaps living 20 to 30 years, and can be an important indicator of water quality. The fish host species in Washington are unknown, but in northern California, Hardhead (*Mylopharodon conocephalus*), Pit Sculpin (*Cottus pitensis*), and Tule Perch (*Hysterocarpus traski*) are hosts for Western Ridged Mussels.

Western Pearlshell: The average life span is approximately 60 to 70 years, although some individuals are thought to have lived more than 100 years. Because this species is sedentary, sensitive to environmental changes, and long-lived, it can be an excellent biological indicator of water quality. Documented host fishes for Western Pearlshells include Cutthroat Trout (*Oncorhyncus clarkii*), Rainbow/Steelhead Trout (*O. mykiss*), Chinook Salmon (*O. tshawytscha*), and Brown Trout (*Salmo trutta*), and a number of other fish are considered potential hosts.

Distribution and Abundance

California Floater/Winged Floater: Historically widespread west of the Continental Divide from British Columbia to Baja, but extirpated from many areas by dams. It is problematic to determine the distribution of these species because of their morphological similarity and confusion of taxonomy; this range description may prove to apply to several distinct species. Frest and Johannes (1995) reported the range has been reduced and extant populations were found in the following areas: the Middle Snake River in Idaho; the Fall and Pit Rivers in Shasta County, California; the Okanogan River in Chelan County, Washington; and Roosevelt and Curlew Lakes in Ferry County, Washington. Extirpated from much of historic range, including the Willamette and lower Columbia Rivers and the Central Valley in California.

Western Ridged Mussel: The Western Ridged Mussel is widely distributed in Washington, Oregon, California, Idaho, Nevada, and southern British Columbia. This species is more common east of the Cascades of Oregon and Washington than on the western side. In Washington, the Western Ridged Mussel was known from the Columbia River (Kittitas County), Toppenish Creek (Yakima County), Yakima River (Benton County), the Snake River (Columbia County), Chehalis River (Grays Harbor, Lewis Counties), Skookumchuck River (Lewis County), Spokane River (Lincoln County), the Columbia, Okanagan, Similkameen, Spokane and Little Spokane Rivers, Osoyoos Lake, Palmer and Hangman Creeks, and Spokane Falls (Okanagan County), and Colville River (Stevens County). Declines or extirpations have been reported in the Little Spokane, Wenatchee, and Yakima Rivers.

Western Pearlshell: The range of the Western Pearlshell extends from Alaska and British Columbia south to California and east to Nevada, Wyoming, Utah and Montana; it is apparently most abundant in Oregon, Washington, Idaho and British Columbia. In Washington, Pearlshells have been extirpated from much of the mainstem Columbia and Snake Rivers; substantial declines, die-offs, or lack of recent reproduction have also been reported from the SanPoil River (Ferry County), Kettle River (Stevens County), the Little Spokane River (Spokane County), Snohomish River, Muck Creek (Pierce County), Bear Creek (King County), and Nason Creek (Chelan County). High levels of arsenic and organochlorine pesticides were found in the tissues of other mussel species collected from the mid-Columbia River during that survey. This species has also been extirpated from northern Nevada, from most areas in northern Utah, several rivers in Montana, and numerous other locations. In addition, there are reports of populations of Western Pearlshells that apparently have not reproduced for decades. Populations of such a long-lived species may appear stable, when in fact they are not reproducing; populations showing repeated reproduction, evidenced by multiple age classes, are now rare.

Habitat

Freshwater mussels are found in shallow habitats in permanent bodies of water, including creeks, rivers, and ponds generally at low elevations. Mussels tend to concentrate in areas of streams with consistent flows and stable substrate conditions. They are often absent or sparse in high-gradient, rocky rivers, but are frequently encountered in low-gradient creeks and rivers, perhaps because they provide a variety of habitat conditions, reliable flow, good water quality, and diverse fish communities.

California Floater/Winged Floater: Floaters occur in natural lakes, reservoirs, and downstream low-gradient reaches of rivers in pool habitats. Because their thin shells are prone to damage, floaters favor habitats of sand and silt substrates in lower gradient streams than those favored by Western Pearlshells and Western Ridged Mussels; sandbars near the mouths of tributary streams or below riffles are important habitats.

Western Ridged Mussel: Western Ridged Mussels inhabit the bottom of cold creeks, rivers, and lakes from low to mid-elevations with substrates that vary from gravel to firm mud, and include at least some sand, silt or clay. It is generally associated with constant flow, shallow water (less than 10 feet in depth), and well-oxygenated substrates. This species is often present in seasonally turbid streams, but absent from continuously turbid water (e.g. glacial meltwater streams).

Western Pearlshell: This species inhabits cold creeks and rivers with clear, cold water and sea-run salmon or native trout including waterways above 5,000 feet in elevation. Western Pearlshells are typically found at depths of 1.5 to 5 feet, and they tend to congregate in areas with boulders and gravel substrate, with some sand, silt and clay. Western Pearlshells occur in waterways with low velocities and stable substrates and are frequently found in eddies or pools and areas with stones or boulders that likely shelter mussel beds from scour during flood events. This species appears to be intolerant of sedimentation.

References

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Families Unionidae and Margaritiferidae: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
California Floater					
1	Agriculture and aquaculture side effects	Water level fluctuations; pollution	Protect water quality	Current insufficient	External
2	Resource information collection needs	Taxonomic uncertainty may mean one or more taxa are in greater decline	Taxonomic clarification	Current insufficient	External
Western Pearlshell					
1	Fish and wildlife habitat loss or degradation	Pollution, siltation	Protect water quality	Current insufficient	External
2	Agriculture and aquaculture side effects	Pollution, siltation	Protect water quality	Current insufficient	External
3	Fish and wildlife habitat loss or degradation	Suction dredging for gold	Delineate and protect sites	Current insufficient	Both
Western Ridged Mussel					
1	Fish and wildlife habitat loss or degradation	Pollution; need info on life history, ecology	Protect water quality	Current insufficient	External
2	Resource information collection needs	Need info on life history, ecology	Life history research	Current insufficient	External
Winged Floater					
1	Agriculture and aquaculture side effects	Water level fluctuations; pollution; need taxonomic clarification	Technical assistance to regulatory agencies	Current insufficient	Both
2	Resource information collection needs	Need taxonomic clarification	Taxonomic clarification;	Current insufficient	External

NOTE: Numbers are for reference only and do not reflect priority.

MARINE BIVALVE

OLYMPIA OYSTER (*Ostrea lurida*)

Conservation Status and Concern:
Washington's only native oyster, it is currently present in diminished abundance (less than five percent) due to overharvest and habitat alterations throughout most of the species historical range (circa 1850) in Washington. Evidence of natural recruitment and restoration success observed but lack of suitable habitat limits further increases.

Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend	Climate Vulnerability
None	Candidate	Yes	G5	SNR	Low/stable	High

Biology and Life History


Photo: Wikipedia Commons

Olympia Oysters are hermaphroditic and able to alternate between male and female annually during reproduction cycles. Sexual maturity is observed in oysters greater than 0.6 inch shell length, which is typically reached in 12 months. Fecundity is observed to be very high for young oysters in comparison to older oysters. Fertilized larvae are initially brooded internally by the female and then released as large, free-swimming pediveligers for 7 to 10 days before settlement and attachment to available hard substrates. Populations are tolerant of a wide range of environmental conditions and salinity values but are intolerant of freshwater exposures. Intertidal survival is dependent upon thermal refuges provided by immersion, partial immersion, moist substrates, or by location on or underneath rocks, boulders, oysters or other structure. Extreme freezing weather events may result in significant mortalities in exposed intertidal occurrences. Maximum adult size appears to be 3.5 inches but typically they range from 2 to 2.4 inches, reached in five to six years. Maximum age is generally 10 years.

Distribution and Abundance
Olympia Oysters are native along the Pacific coast of North America, form Gale Passage (British Columbia) to Bahia de San Quintin (Baja California). Primarily found, historically and currently, in the low intertidal zone in Puget Sound with rare subtidal occurrences. In Willapa Bay the species occurred both in the intertidal and subtidal historically but now appear to be limited to subtidal occurrences. Occurrences in Grays Harbor appear to be historically and currently of very limited abundance. Present throughout nearly all of the species historical range in Washington. While currently found in diminished abundance, the species is commonly observed intertidally in portions of Hood Canal, South Puget Sound, and Central Puget Sound plus specific embayments in North Sound, Admiralty Inlet and Straits of Juan de Fuca. Dense occurrences in natural beds are limited and estimated to be less than five percent of total historical extents and numbers of beds (circa 1850). The Willapa Bay population exhibits observable larval production but abundance of adults remains unknown. Adults are occasionally observed in Grays Harbor. Natural recruitment success in portions of Puget Sound appears to be on the increase.

Habitat
Olympia Oysters occur primarily as an intertidal species in Puget Sound and both intertidal and subtidal in Willapa Bay. They form shallow (less than two feet in elevation) loose beds of oysters and shell on unconsolidated mud, sand, gravel substrates. They may also be found attached to rocky structures. The species requires hard substrates (oysters, shell, gravel, rock) for attachment of recruits and formation of natural beds.

References
Blake, B. and A. Bradbury. 2012. Plan for Rebuilding Olympia Oyster (*Ostrea lurida)* Populations in Puget Sound with a Historical and Contemporary Overview. Washington Department of Fish and Wildlife, Olympia.

Olympia Oyster: Conservation Threats and Strategies

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
1	Invasive and other problematic species	Localized occurrences of the non-native predators *Ocinebrellus inornatus* and *Koinostylochus ostreaophagus.*	Re-establish or enhance presence of viable, self-sustaining source populations.	Current sufficient	Both
2	Overharvesting of biological resources	By-catch mortality from Pacific Oyster commercial harvest and other uses of tidelands	Re-establish or enhance presence of viable, self-sustaining source populations.	Current sufficient	Both
3	Fish and wildlife habitat loss or degradation	Shoreline and tideland modifications, including nearshore or estuarine restoration projects.	Re-establish or enhance presence of viable, self-sustaining source populations.	Current sufficient	Both
4	Fish and wildlife habitat loss or degradation	Siltation from upland practices and nutrient inputs	Re-establish or enhance presence of viable, self-sustaining source populations.	Current sufficient	Both
5	Agriculture and aquaculture side effects	Genetic fitness impacts from unrestricted distribution of generic hatchery-origin native oysters	Re-establishment and enhancement of genetic diversity through restoration historic and new sites.	Current sufficient	Both

NOTE: Numbers are for reference only and do not reflect priority.

MARINE GASTROPOD

PINTO ABALONE (*Haliotis kamtschatkana*)

Conservation Status and Concern

The Pinto Abalone has failed to recover from dramatic declines resulting from excessive recreational and illegal harvest, despite fishery closure. There is strong evidence of recruitment failure, perhaps because the densities of remaining populations are below the threshold for successful reproduction.

Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend	Climate Vulnerability
None	Candidate	Yes	G3G4	SNR	Uncommon/declining	Moderate-high

Biology and Life History

Photo: Wikimedia Commons

Adult Pinto Abalone feed primarily on drift macroalgae, such as bull kelp (*Nereocystis luetkeana*), and juveniles feed predominantly on microalgae and diatoms. Pinto Abalone are broadcast spawners and the sperm and eggs are only viable for a short period, so successful reproduction requires that adults be aggregated. After eggs are successfully fertilized, embryos rapidly become free-swimming trochophores, which metamorphose into veliger larvae. After approximately 10 to 14 days as plankton, the swimming veligers settle onto suitable substrate. Newly settled juvenile abalone require crevices for added protection from predators and remain cryptic until mature. Upon maturation at approximately two inches in shell length, abalone become more exposed and are more easily found in their habitat. Many are semi-exposed or fully exposed on open rocky habitat by the time they reach 3.5 inches in shell length.

Distribution and Abundance

Pinto Abalone are distributed from Point Conception, California to southeast Alaska. In Washington, they are generally found on hard, rocky substrates in exposed coastal areas, including Puget Sound, Strait of Juan de Fuca and the San Juan Archipelago. Abundance at index sites in the San Juan Islands declined 92 percent between 1992 and 2013.

Habitat

Pinto Abalone are typically found on rocky substrate, in water between 10 and 65 feet deep. Their preferred habitat in the San Juan Archipelago and the Strait of Juan de Fuca is exposed rock, often covered (at least partially) with crustose coralline algae.

References

Vadopalas, B. and J. Watson. 2014. Recovery Plan for Pinto Abalone (*Haliotis kamtschatkana*) in Washington state. Puget Sound Restoration Fund. 50 pp.

Pinto Abalone: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
1	Resource information collection needs	Reproductive failure due to low densities	Research augmentation methods	Current insufficient	WDFW
2	Overharvesting of biological resources	Reproductive failure due to low densities	Life history research	Current insufficient	WDFW
3	Overharvesting of biological resources	Small populations vulnerable to illegal harvest	Outreach and enforcement of harvest restrictions	Current insufficient	WDFW
4	Resource information collection needs	Limited understanding of life history and limiting factors	Life history research	Current insufficient	WDFW

NOTE: Numbers are for reference only and do not reflect priority.

EARTHWORM

GIANT PALOUSE EARTHWORM (*Driloleirus americanus*)

Conservation Status and Concern

Data on this species are sparse. It is difficult to detect and few surveys have been performed to determine its distribution and abundance. There has been an obvious reduction of range in the Palouse region of Washington with conversion of prairie to cropland. Introduced worm species appear to exclude native species, including this one.

Federal Status	State Status	PHS	Global Ranking	State Ranking	Population size/trend	Climate Vulnerability
None	Candidate	Yes	G1	S2	Unknown/unknown	Low-moderate

Taxonomic note: A genetics study is currently underway to determine whether the worms found in the East Cascades are the same as those found in the Palouse regions of Washington and Idaho. Preliminary findings indicate that these populations are likely the same species.

Biology and Life History

A large, pale or white earthworm, this species has until relatively recently been considered endemic to the Palouse prairies of eastern Washington and Idaho, where it was discovered in 1897. This species is considered to be “anecic”, meaning that it burrows vertically deep into the ground and lives in deep, semi-permanent burrows, coming to the surface in wet conditions. Burrows have been found at a depth of 15 feet.

Giant Palouse Earthworm
Photo: M. Teske

Distribution and Abundance

In Washington, the Giant Palouse Earthworm has been found in Chelan, Kittitas and Whitman Counties. It may be more widespread because recent records from the east slope of the Cascades have expanded its known range. Based on knowledge of other species in the Megascolecidae family to which this species belongs, the worm’s range could extend along the Columbia Plateau in a band just below the terminal moraines of the Pleistocene glaciation. Because these worms are very slow colonists, range limits are probably determined by the extent of Pleistocene glaciation and the Missoula Floods, both of which would have eliminated earthworms.

Habitat

Originally assumed to require deep, loamy soils characteristic of the Palouse bunchgrass prairies, the species was found in the eastern Cascades occupying gravelly sandy loam and other rocky soils in forested areas. They have been found in open forest, shrub-steppe, and prairie. Of sites surveyed, only one occurrence was in non-native vegetation on land enrolled in the Conservation Reserve Program.

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J. Maynard-Johnson, University of Idaho, pers.comm.
K. McAllister, WSDOT, pers.comm.

Giant Palouse Earthworm: Conservation Threats and Actions

	STRESSOR	DESCRIPTION	ACTION NEEDED	LEVEL OF INVESTMENT	LEAD
1	Agriculture and aquaculture side effects	In the Palouse region, plowing and soil disturbance due to agricultural activity has converted GPE habitat	Surveys are needed in undisturbed areas to determine site occupancy.	Nothing current - new action needed	Both
2	Resource information collection needs	Originally found in Palouse prairie and thought to be endemic there, but recent detections in the East Cascades and clues regarding range characteristics indicate the need for greater survey efforts	Past surveys have been conducted in the Palouse region. East Cascades detections were accidental at first. Very limited, spot surveys done since.	Current insufficient	External
3	Resource information collection needs	Questions remain regarding possible genetic differences between the Palouse and East Cascade populations	Research on genetics being done by J. Maynard-Johnson at University of Idaho. Results not definitive.	Current sufficient	External
4	Fish and wildlife habitat loss or degration	WSDOT highway and USFS road building and alteration have disrupted earthworm concentrations. This is how they were discovered in the East Cascades.	Review of proposed transportation projects	Current insufficient	Both
5	Invasive and other problematic species	Invasive, non-native earthworm species, notably the European earthworm (*Lumbricus terrestris*).	Note occurrences and continue surveys	Current insufficient	Both

NOTE: Numbers are for reference only and do not reflect priority.

REFERENCES

SECTION A: Alphabetical list of species

SECTION B: Explanation of Terms

Conservation Status Table

Federal Status: Refers to legal designations under the Federal ESA (listed as Endangered or Threatened or recognized as a Candidate species for listing), or designated as a Sensitive species.

State Status: The Washington Fish and Wildlife Commission has classified 46 species as Endangered, Threatened or Sensitive, under WAC 232-12-014 and WAC 232-12-011. Species can also be designated Candidate Species for state listing by WDFW policy.

PHS (Priority Habitats and Species Program): A species listed under the PHS program is considered to be a priority for conservation and management and requires protective measures for survival due to population status, sensitivity to habitat alteration and/or tribal, recreational or commercial importance. Management recommendations have been developed for PHS species and habitats, and can assist landowners, managers and others in conducting land use activities in a manner that incorporates the needs of fish and wildlife.

Global (G) and State (S) Rankings: Refers to NatureServe status rankings provided by the Natural Heritage Program. These conservation status ranks complement legal status designations and are based on a one to five scale, ranging from critically imperiled (1) to demonstrably secure (5). The global (G) and state (S) geographic scales were used for the SGCN species fact sheets. For more on the methodology used for these assessments, please see: Methodology for Assigning Ranks - NatureServe.

State Rank: characterizes the relative rarity or endangerment within the state of Washington.
S1 = Critically imperiled
S2 = Imperiled
S3 = Rare or uncommon in the state – vulnerable
S4 = Widespread, abundant, and apparently secure i
S5 = Demonstrably widespread, abundant, and secure in the State
SA = Accidental in the state.
SE = An exotic species that has become established in the state.
SH = Historical occurrences only are known, perhaps not verified in the past 20 years, but the taxon is suspected to still exist in the state.
SNR = Not yet ranked. Sufficient time and effort have not yet been devoted to ranking of this taxon.
SP = Potential for occurrence of the taxon in the state but no occurrences have been documented.
SR = Reported in the state but without persuasive documentation which would provide a basis for either accepting or rejecting the report (e.g., misidentified specimen).
SRF = Reported falsely in the state but the error persists in the literature.
SU= Unrankable. Possibly in peril in the state, but status is uncertain. More information is need.
SX = Believed to be extirpated from the state with little likelihood that it will be rediscovered.
SZ = Not of conservation concern in the state.

Qualifiers are sometimes used in conjunction with the State Ranks described above:
B - Rank of the breeding population in the state.
N - Rank of the non-breeding population in the state.

Global Rank: characterizes the relative rarity or endangerment of the element world-wide.
G1 = Critically imperiled globally
G2 = Imperiled globally
G3 = Either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range - vulnerable
G4 = Widespread, abundant, and apparently secure globally
G5 = Demonstrably widespread, abundant, and secure globally, though it may be quite rare in parts of its range
GH = Historical occurrences only are known, perhaps not verified in the past 20 years, but the taxon is suspected to still exist somewhere in its former range.
GNR = Not yet ranked. Sufficient time and effort have not yet been devoted to ranking of this taxon.
GU = Unrankable. Possibly in peril range-wide but status uncertain. More information is needed.
GX = Believed to be extinct and there is little likelihood that it will be rediscovered.

Qualifiers are used in conjunction with the Global Ranks described above:
Tn Where n is a number or letter similar to those for Gn ranks, above, but indicating subspecies or variety rank. For example, G3TH indicates a species that is ranked G3 with this subspecies ranked as historic.

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J. Maynard-Johnson, University of Idaho, pers.comm.

K. McAllister, WSDOT, pers.comm.

D. Ruiter, University of Texas, pers.comm.

Appendix B

Potential Range and Habitat Distribution Maps

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Appendix B
Potential Range and Habitat Distribution Maps

B.0 Overview

This appendix describes the methodology for developing potential range and habitat distribution maps. It includes maps generated for a subset of the Species of Greatest Conservation Need (SGCN). The maps were built specifically to reflect the following information for each individual species:

- Known occurrences;
- Potential habitat distribution; and
- Areas where conservation actions are being, or could be, applied.

These maps are referred to as "potential" habitat distribution maps because they depict range as areas with documented occurrences, as well as areas with suspected or possible occupancy based on the availability of suitable habitat and the proximity of that suitable habitat to occupied areas.

Since these maps are based on occurrence data, maps were generated only for those species for which sufficient data existed in our database. Species were prioritized for initial map development based in part on WDFW's immediate need for spatial distribution data. For example, we prioritized map development for the following species:

- Those that will be covered in the Wildlife Areas Habitat Conservation Plan, currently in preparation by WDFW; and
- Those for which the agency is currently, or will soon, develop status assessments.

These maps are identified as "working drafts" because, as we become more familiar with these map products and their utility for conservation planning, and as new data becomes available, we intend to refine these maps and develop additional maps for other SGCN as appropriate. This information is intended to be used in conservation planning, for example to identify and prioritize areas for population surveys or to determine priority areas for restoration.

B.1 Methodology

Species range was defined as the geographic area in which a species regularly occurs within Washington, including areas used for breeding as well as important distinct foraging, wintering, or migration areas where appropriate. Range does not include accidental, infrequent, or peripheral areas that are disconnected from the regularly occurring area or wintering or migration areas that are generally broad and nonspecific. We chose to spatially represent range using watershed boundaries (hydrologic units) at various scales and we used ecological systems[1] as the basis for representing potentially suitable habitat distribution of the species within its range. Each step in the process is described below, using the example of the Washington Ground Squirrel.

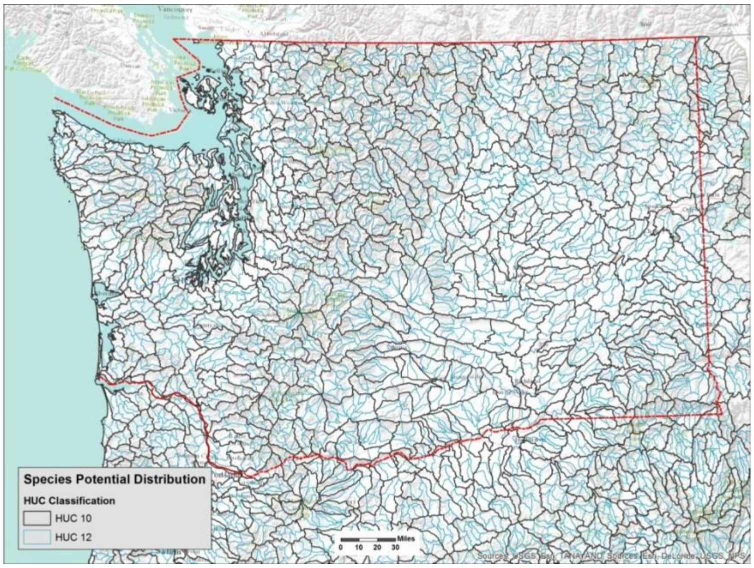
B.1.1 Select Range Units and Scale

We used the United States Geologic Survey (USGS) Hydrologic Unit Code (HUC) national watershed classification system to delineate range. The United States is divided and subdivided into successively smaller hydrologic units which are classified into various levels. The hydrologic units are nested within

[1] Ecological systems are a component of the National Vegetation Classification Scheme (NVCS) and have been used through the State Wildlife Plan Update to describe habitat needs of SGCN.

each other, from the largest geographic area to the smallest. Each hydrologic unit is identified by a unique code (HUC), indicating the relative scale. We selected two units to delineate range; HUC 12 (smaller) and HUC 10 (larger - see figure 1 for the distribution and relative size of HUC 10 and HUC 12 watersheds throughout Washington).

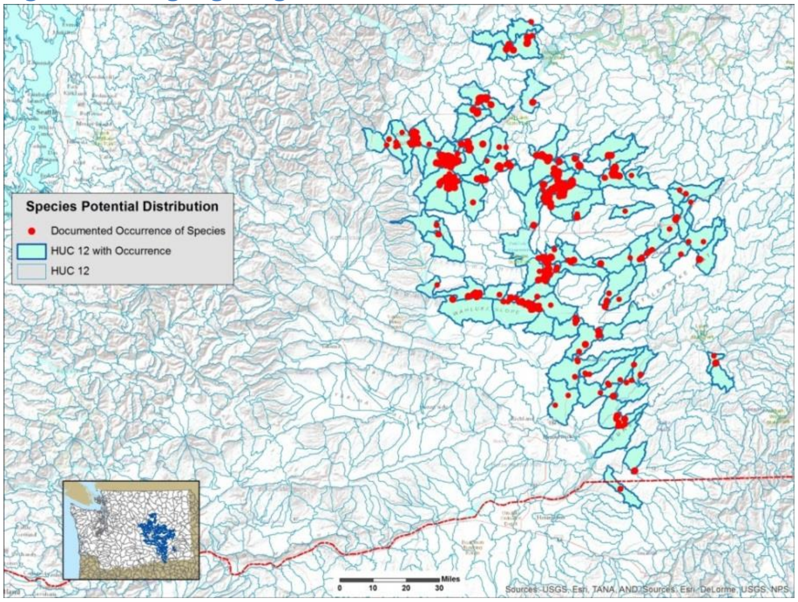
Figure B-1: HUC 10 and HUC 12 Watersheds in Washington



B.1.2 Select HUC 12s

Species occurrence data from the WDFW database was mapped as they occur in HUC 12 watersheds. The data used were considered to have high accuracy and were from 1978 to 2015 (figure 2). HUC 12s were selected based on the presence of species occurrence and used as the core range for the species. This preliminary list was then edited by WDFW biologists who used empirical data and literature to determine extant, incidental, accidental, and infrequent occupancy status for HUC 12s. The resulting HUC 12 selected watersheds represent the highest degree of certainty in depicting the recently occupied species range (Figure 2).

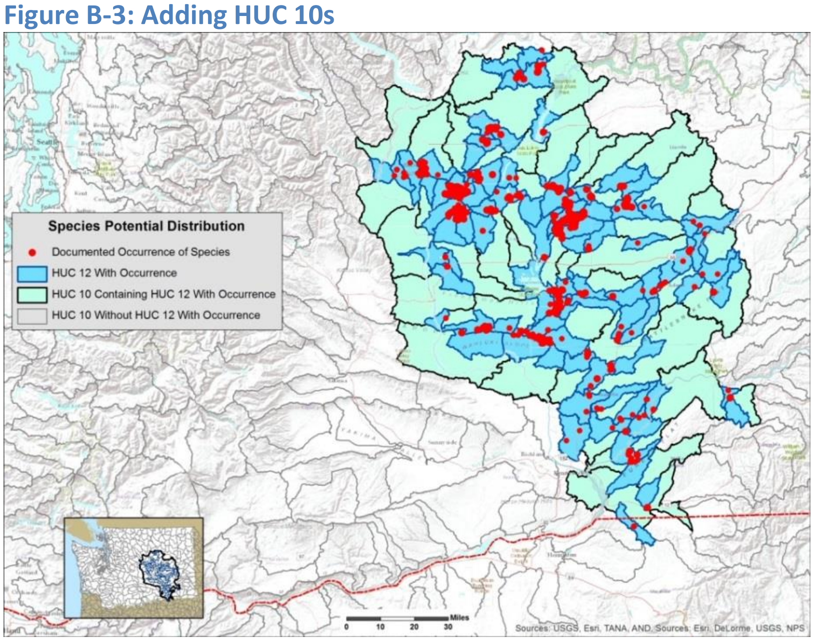
Figure B-2: Highlighting HUC12s with Documented Recent Occurrences of Washington Ground Squirrel



B.1.3 Selectively Highlight Adjacent HUC 10s

The initial set of HUC 12s selected for each species is limited by known occurrence data. However, not every area in the state has been surveyed for all species and, therefore, using only occupied HUC 12s would likely underestimate the range of a species and limit potential conservation action. Since the HUC system is hierarchical, HUC 12s are nested within the larger HUC 10 watershed unit. HUC 10s were then selected based on proximity to HUC 12s that were considered occupied by a species to identify areas that a species has the potential to occur (Figure 4).

Figure B-3: Adding HUC 10s



B.1.4 Identify Potentially Suitable Habitat for Habitat Distribution

We defined habitat distribution as the spatial arrangement of ecological systems[2] suitable for a species within its predefined range. Ecological systems are a classification unit developed by NatureServe and are defined as a group of existing plant community types that tend to co-occur within landscapes sharing similar ecological processes, substrates, and/or environmental gradients (Rocchio and Crawford 2008). The Ecological System classification provides a meso-scale target that is useful for ecological mapping, assessments, and conservation prioritization. While ecological systems include natural and semi-natural vegetation, cover types, as used by the National Vegetation Classification Standard (NVCS), include non-natural vegetation or cover, such as agriculture, introduced vegetation, and development. Because both ecological systems and cover types are geospatially mapped, comparing their distribution in Washington to occurrence points of SGCN was a useful exercise in determining species associations with these two categories.

1. The draft *Field Guide to Washington's Ecological Systems* (Rocchio and Crawford 2008);
2. Ecological system descriptions, as housed in NatureServe, where there is evidence that the system occurs in Washington State, but does not appear in Rocchio and Crawford (2008); and
3. Cover type descriptions, as used by NVCS.

Species were associated with ecological systems on a species-by-species basis for 98 ecological systems in Washington. Biologists used expert knowledge and published habitat associations (Rocchio and Crawford 2008) and preferences to associate ecological systems to species using four categories, closely associated, generally associated, unsuitable, and unknown (figure 5). It should be noted that associated habitat and habitat distribution refers here to the extent of ecological systems with which a species is associated, representing potential suitable habitat. Some, if not all species, respond to finer scale habitats such as vernal pools or forest stand age or condition that cannot necessarily be mapped but may drive where a species occurs.

1. Closely Associated: The species demonstrates preference for the ecological system, as indicated by greater occurrence, high densities, greater reproductive output, or other indicators of preference, than in other ecological systems. A species that is closely associated to individual ecological systems often rely on one to a few ecological systems for a significant part, or all, of its life history requirements.

2. Generally Associated: The species occurs in, but does not prefer, the ecological system, as indicated by lesser occurrence, lower densities, or other indicators of a general relationship with the ecological system. A species that is generally associated with individual ecological systems can typically rely on numerous ecological systems to meet its life history requirements.

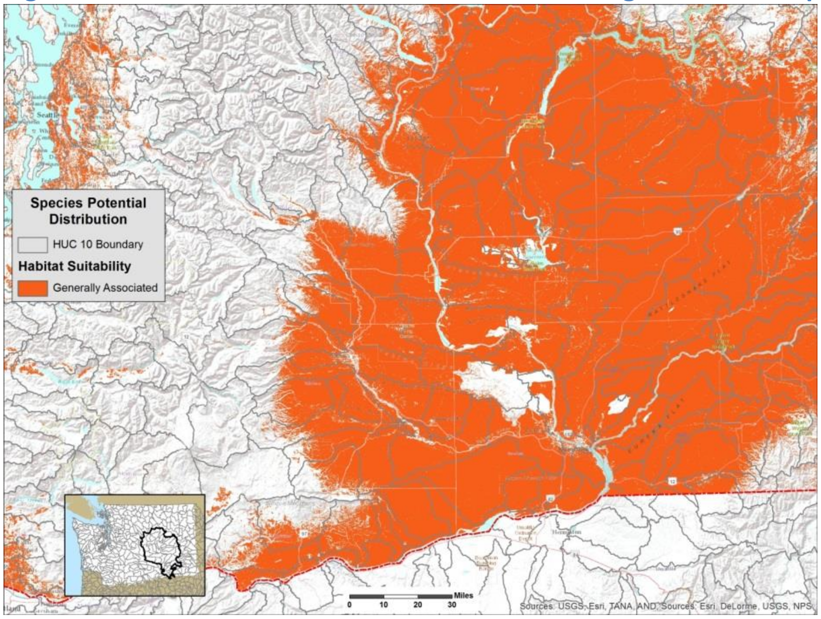
Note: A species can be closely associated with some ecological systems and generally associated with others, given differences in occurrence, densities, reproductive output, or other indicators of preference.

3. Unsuitable: A species demonstrates no use or only occasional use of the ecological system.

4. Unknown: The species' use of the ecological system is unknown. There were questions or uncertainty whether or not a species used an ecological system.

[2] Ecological systems are a component of the National Vegetation Classification Scheme (NVCS) and have been used through the State Wildlife Plan Update to describe habitat needs of SGCN.

Figure B-4: Associated Suitable Habitat for Washington Ground Squirrel in Washington



B.2 Application

As mentioned in the Overview to this section, these maps are intended to be used to inform conservation planning at fairly broad scales to determine the most effective places to direct conservation actions and potential investment. Such actions may include:

1. Conducting species survey efforts in areas that are thought to contain suitable habitat but for which no occurrence data exist;
2. Working with our conservation partners to further evaluate, within watersheds, where specific actions, such as habitat restoration, might take place; and
3. Implementing conservation measures for SGCN on agency-owned and managed lands.

Over time, these activities are expected to lead to further refinement of species ranges, mapped ecological associations, and associated habitat designations.

The maps provided in this appendix are referred to as “potential” species range and distribution maps because they are based on a combination of the factors that define the content of the maps. WDFW makes no assertion that an individual species currently physically occurs across the mapped area. The maps are not meant to be used in a regulatory environment nor replace existing range maps that may have been adopted for use in species recovery planning. They are also not meant to identify specific places for conservation action but rather guide further evaluation within watersheds as to where the most appropriate conservation actions might take place.

B.2.1 Keeping maps relevant

These map products are intended to be dynamic through links to WDFW cooperatively managed wildlife occurrence datasets. WDFW also has strong data sharing partnerships with U.S. Forest Service, Bureau of Land Management, eBird, and other organizations that will be useful in updating species range and habitat distribution maps. Thus maps will be updated and improved based on:

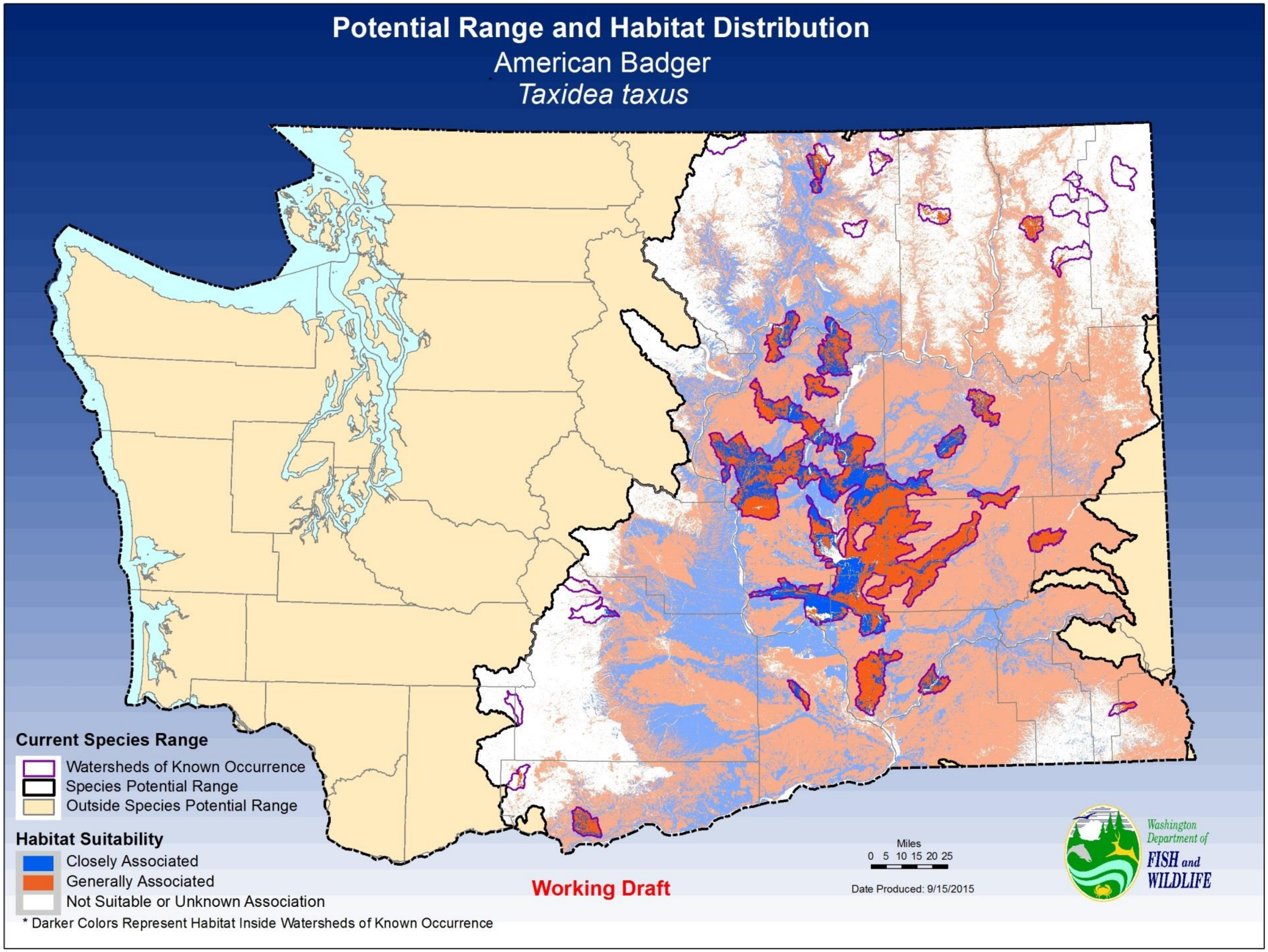
1. The identification of new species occurrences from directed survey efforts by WDFW and/or partners;
2. A better understanding of species associations with ecological systems through research;

3. Refined mapping of ecological systems.

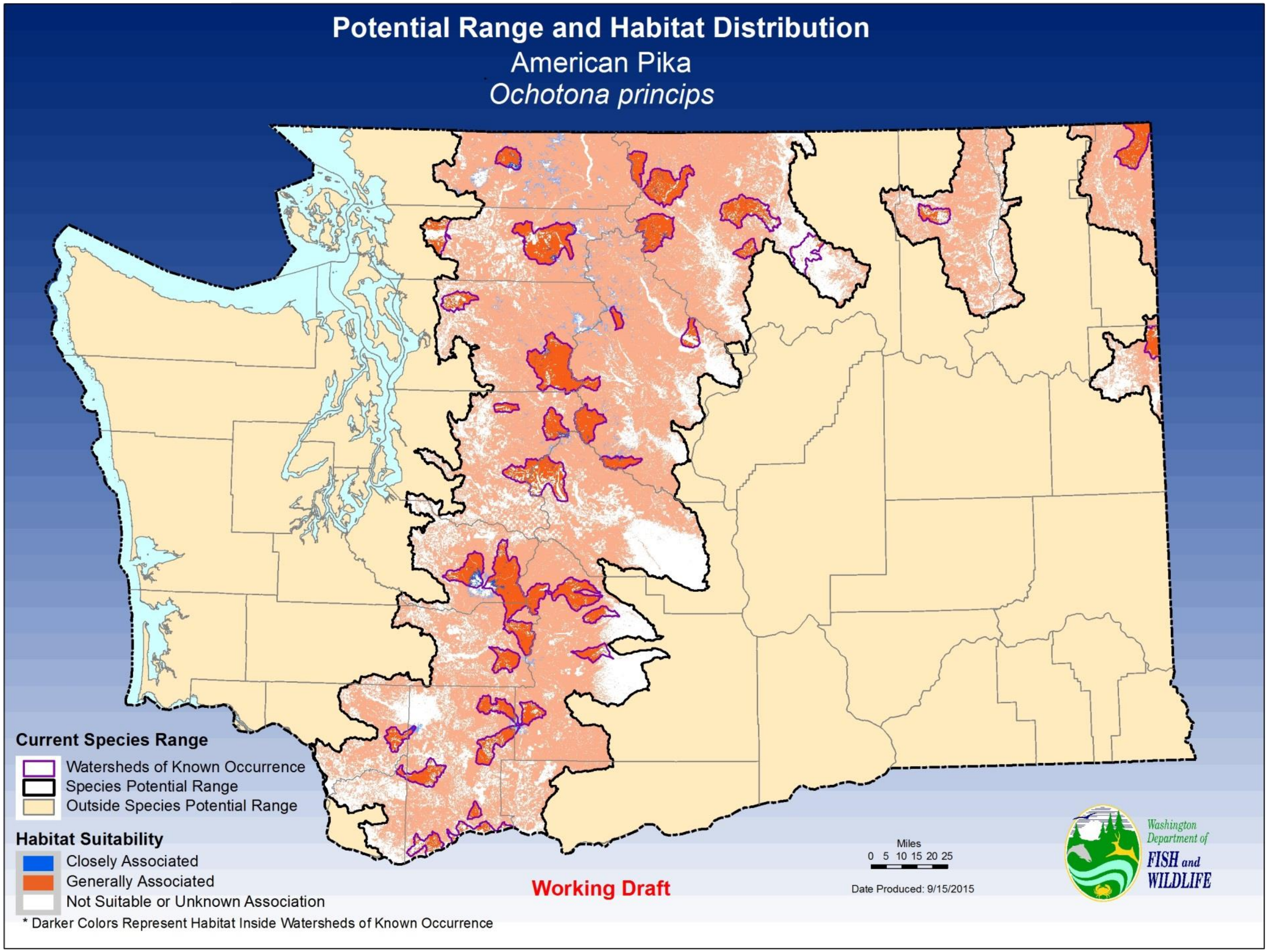
A specific process to update range map products based on the above factors to keep species maps relevant over time will be developed by WDFW. The process will also identify the frequency of updates and the mechanism by which new maps will be disseminated both within WDFW and to conservation partners.

B.3 Range and Potential Habitat Distribution Maps for Selected SGCN

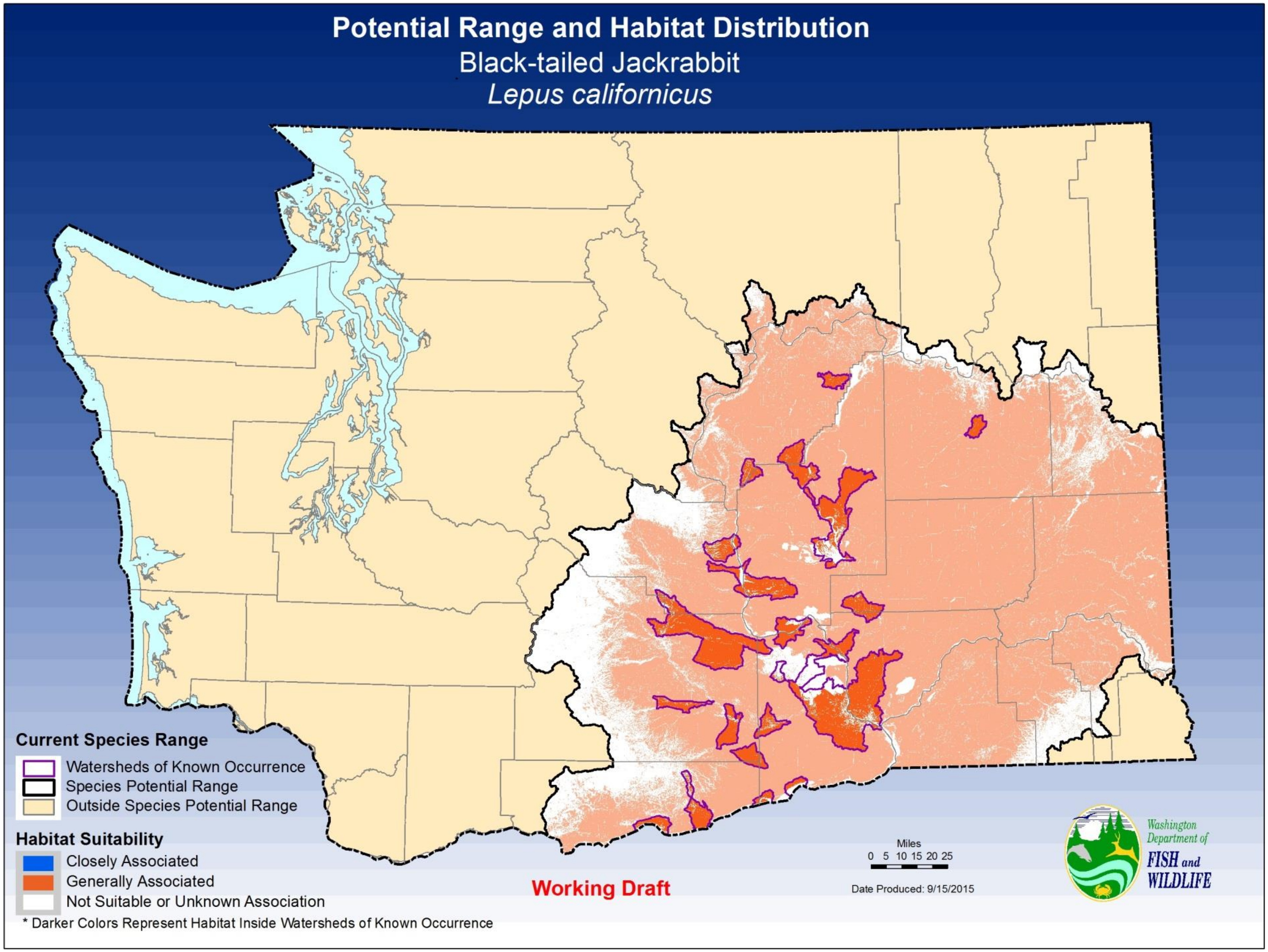
American Badger



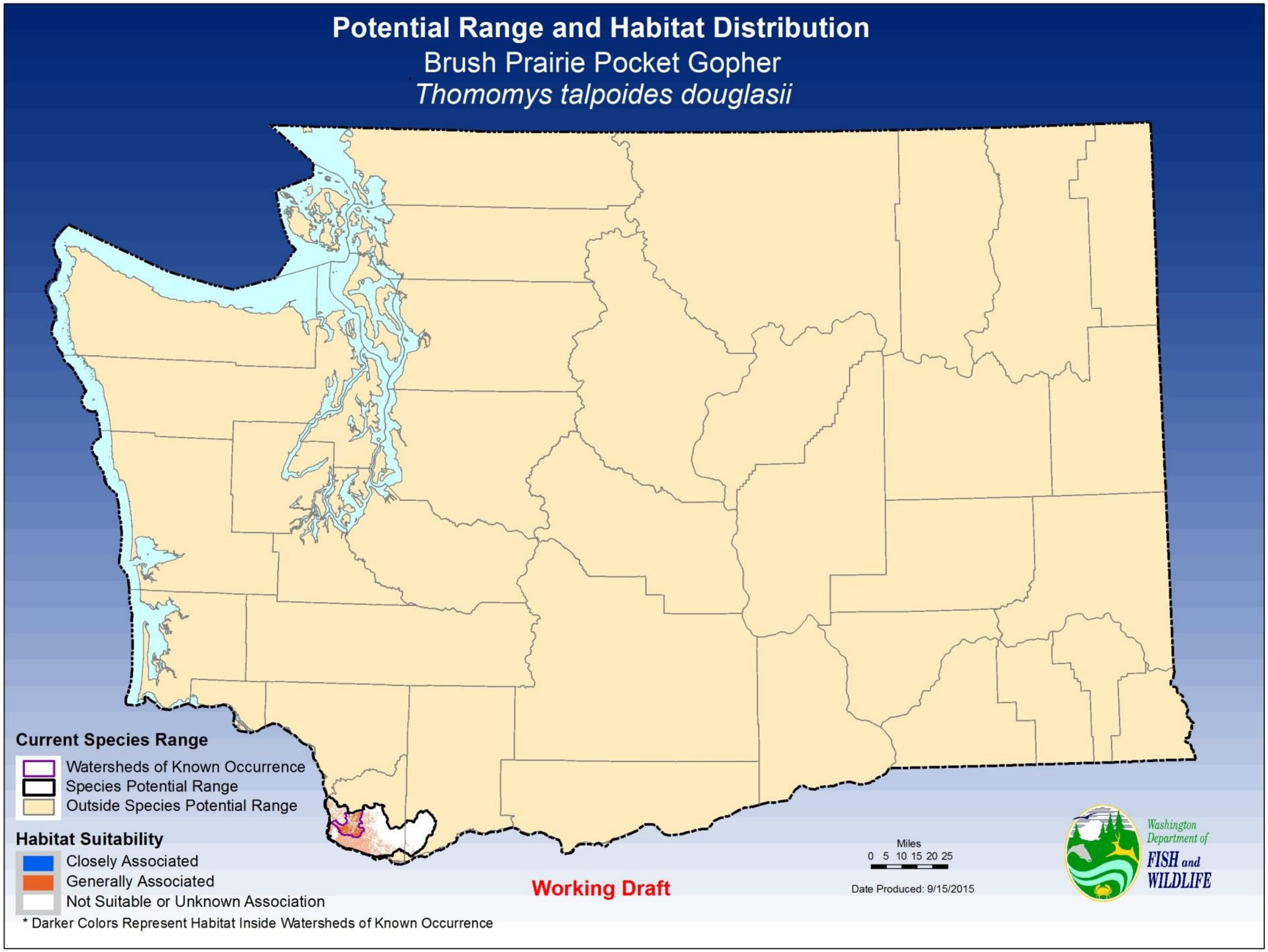
American Pika



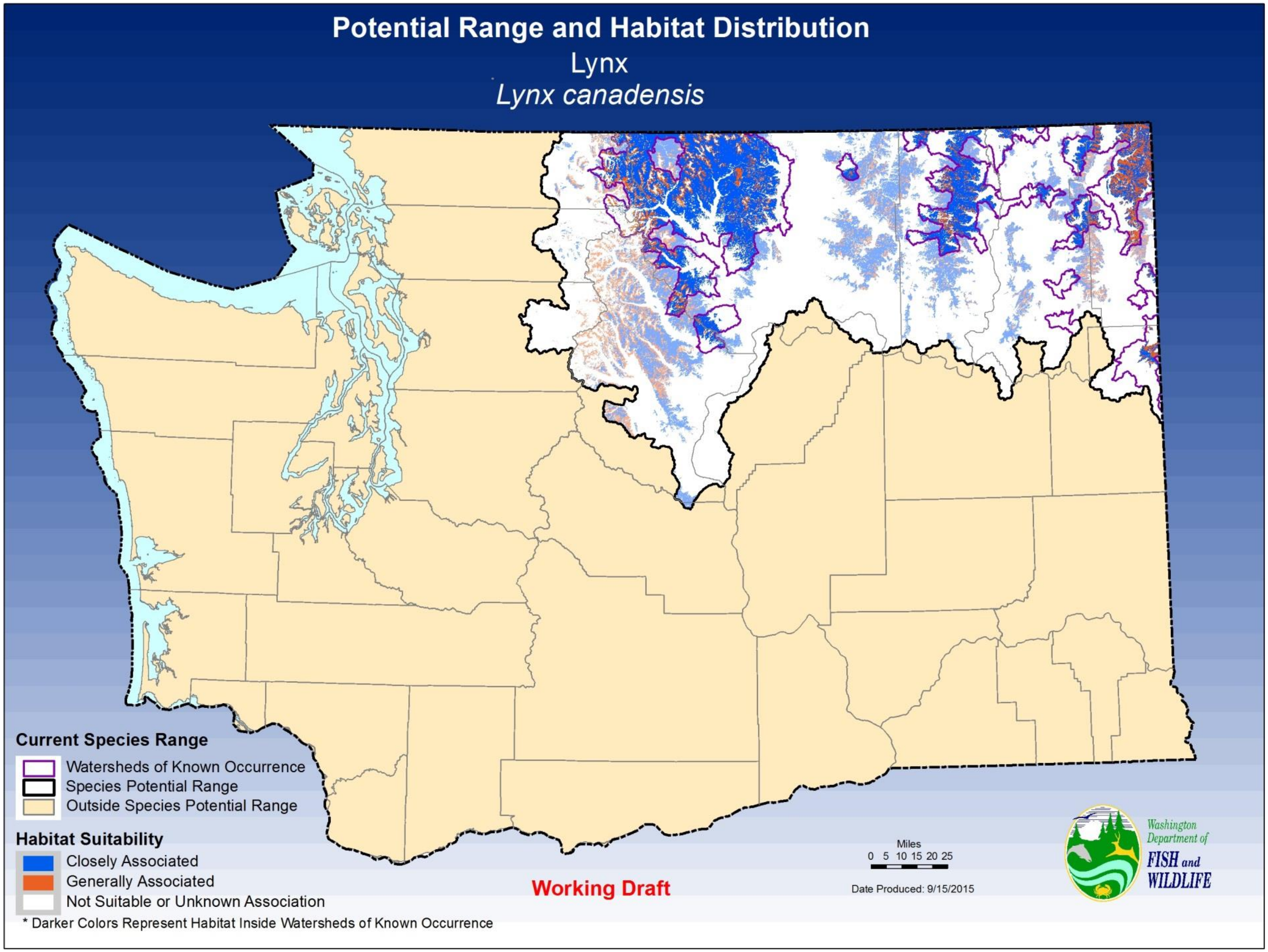
Black-tailed Jackrabbit



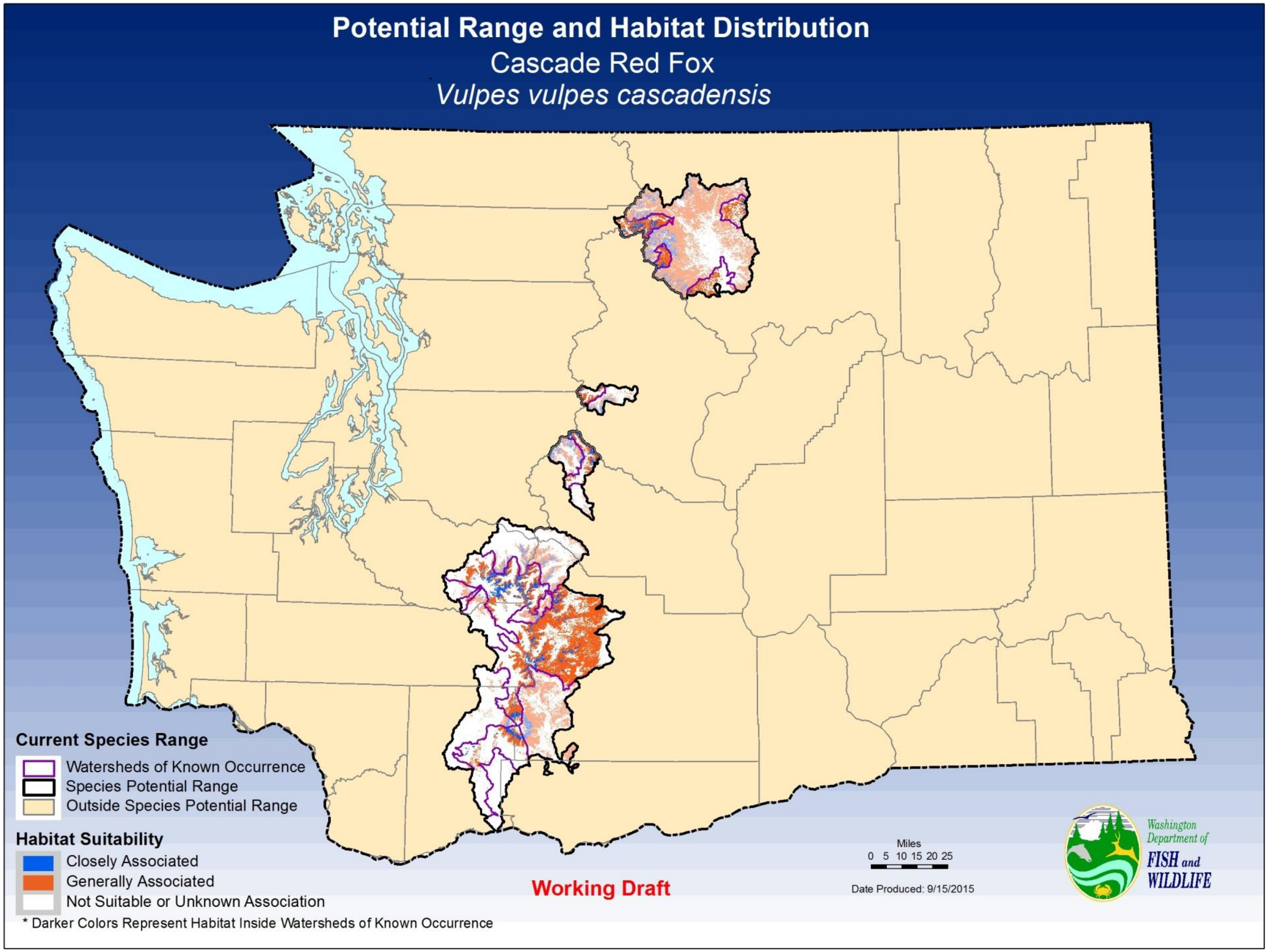
Brush Prairie Pocket Gopher



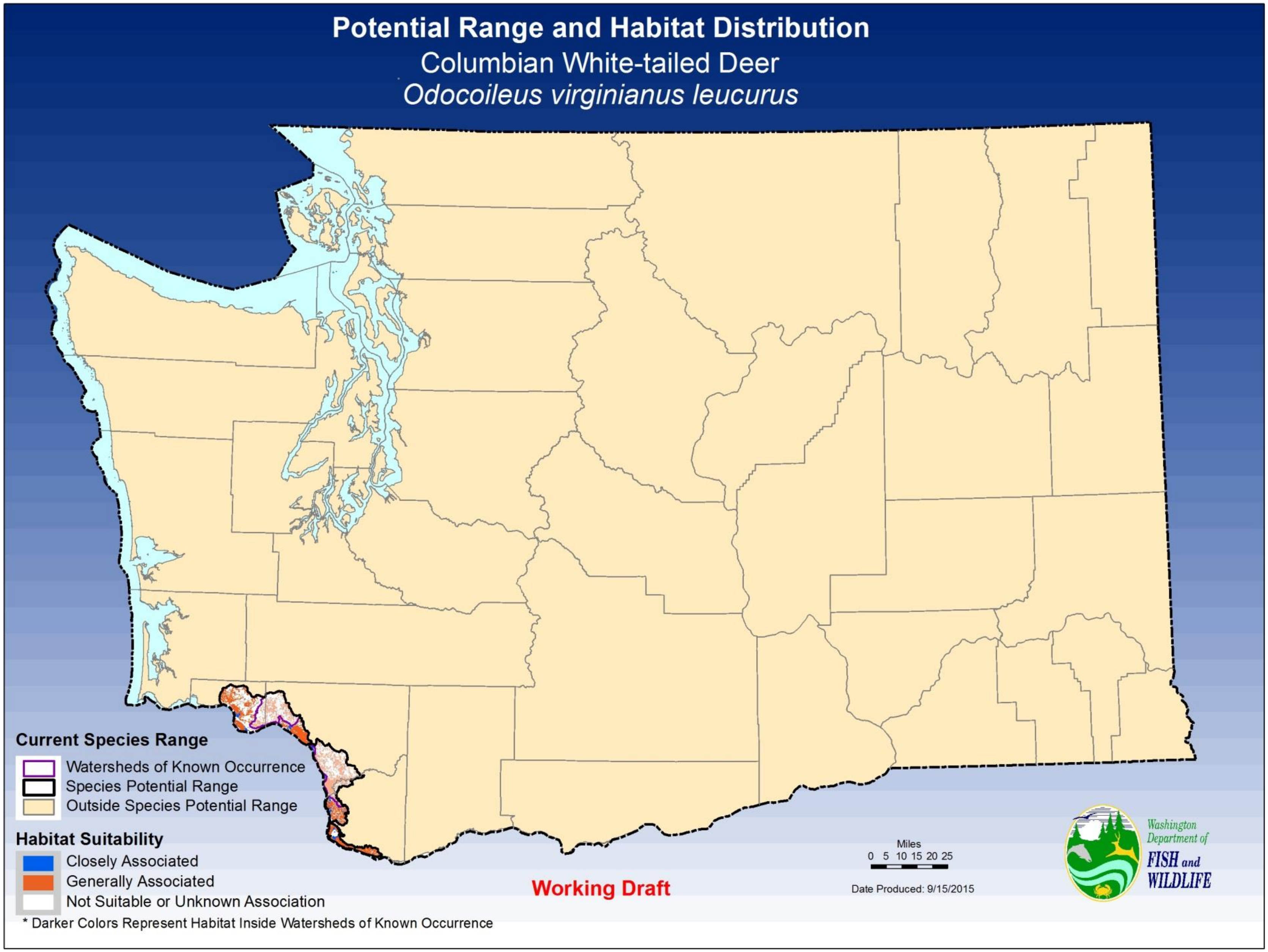
Canada Lynx


Potential Range and Habitat Distribution
Lynx
Lynx canadensis
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

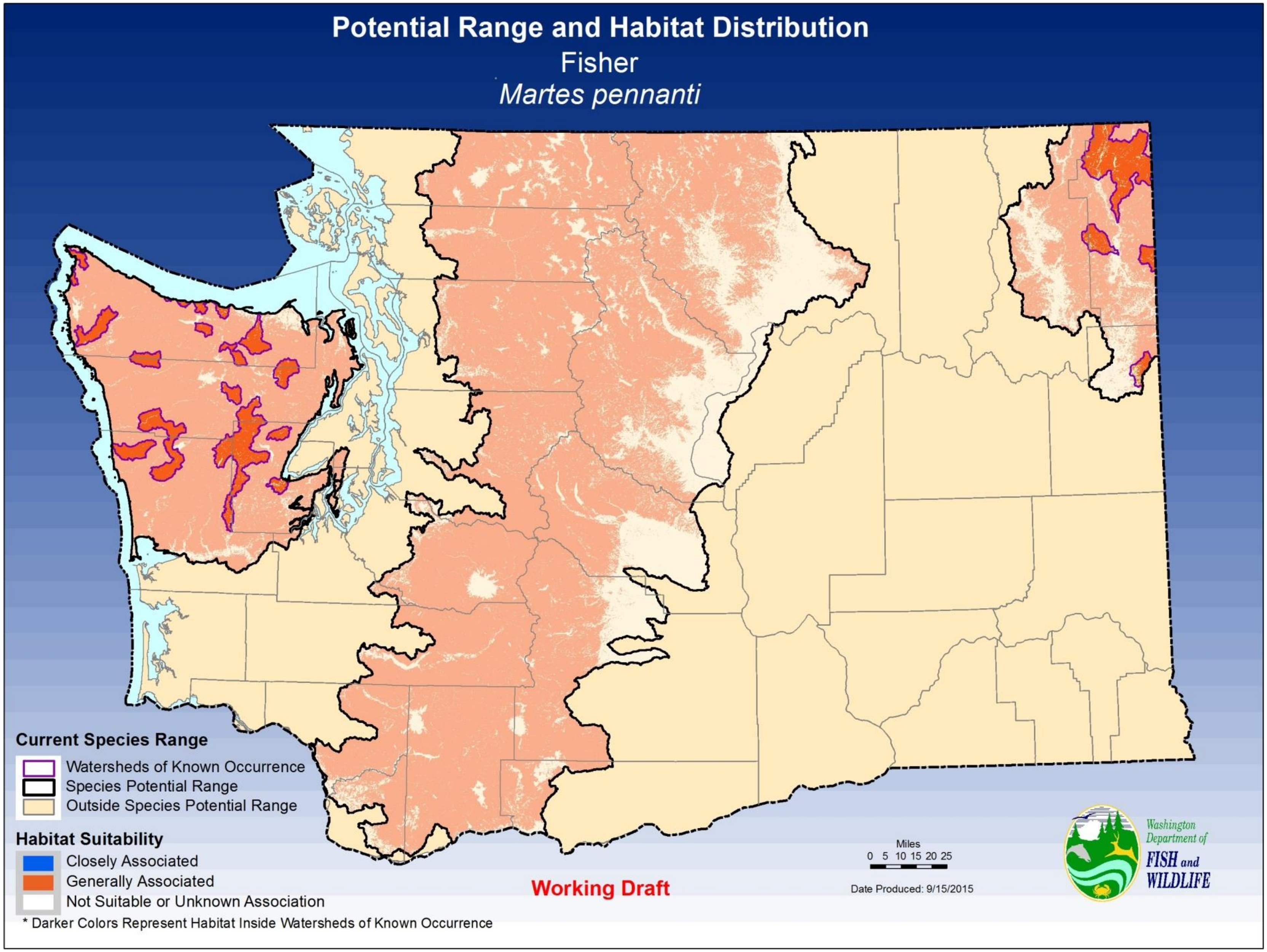
Cascade Red Fox



Columbian White-tailed Deer



Fisher



Potential Range and Habitat Distribution
Fisher
Martes pennanti
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
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Date Produced: 9/15/2015
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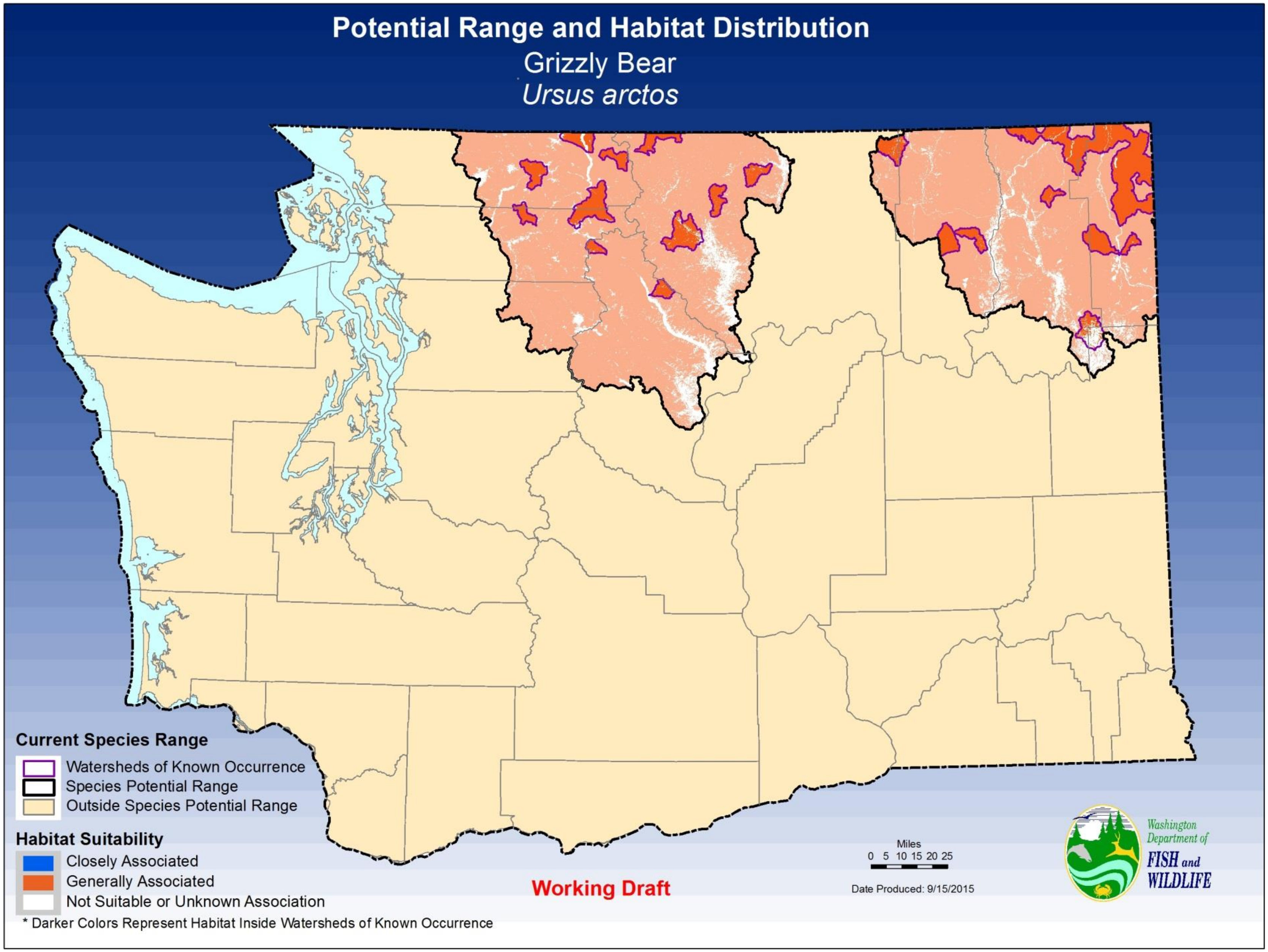
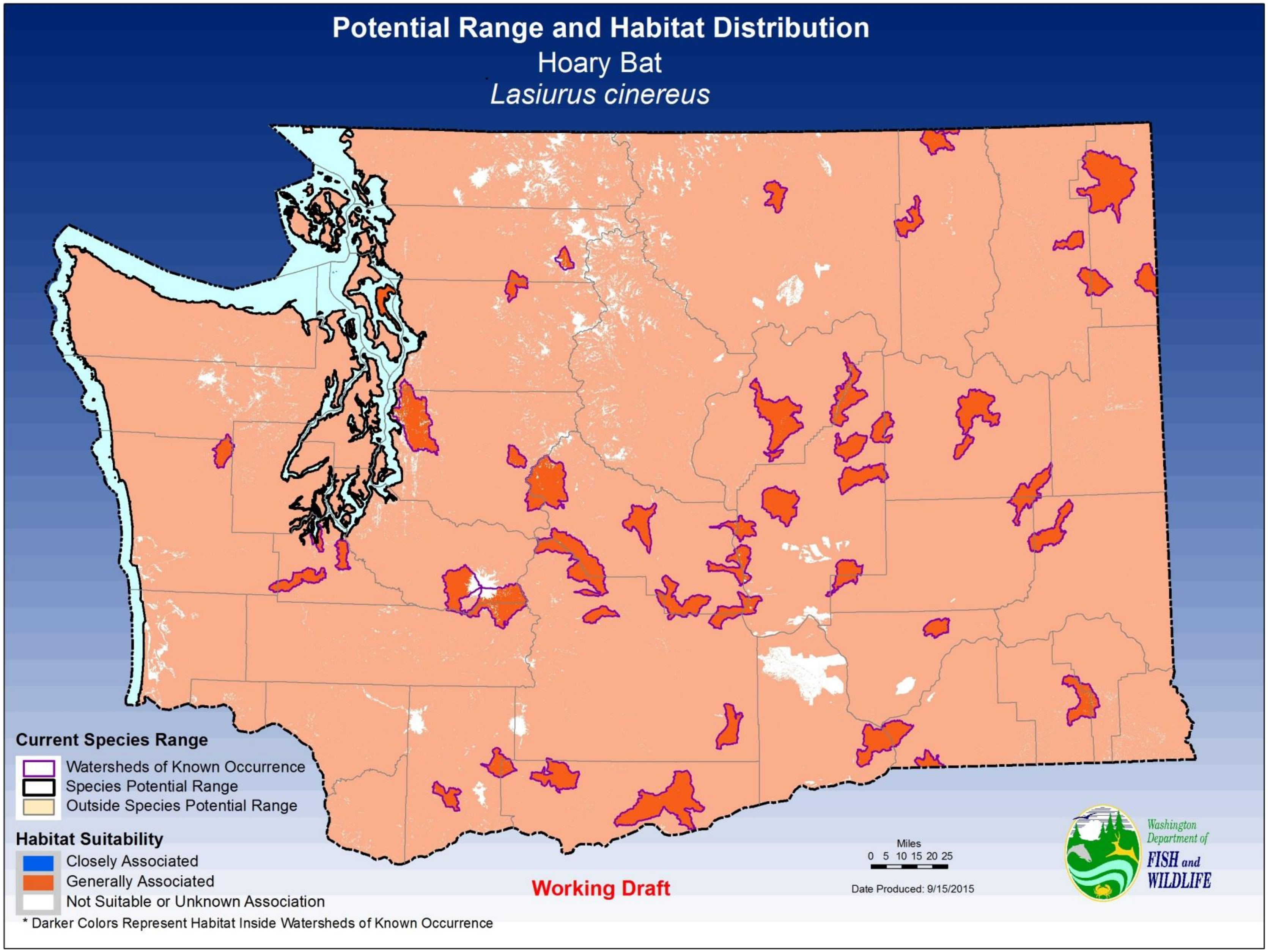
Grizzly Bear



Hoary Bat



Potential Range and Habitat Distribution
Hoary Bat
Lasiurus cinereus
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
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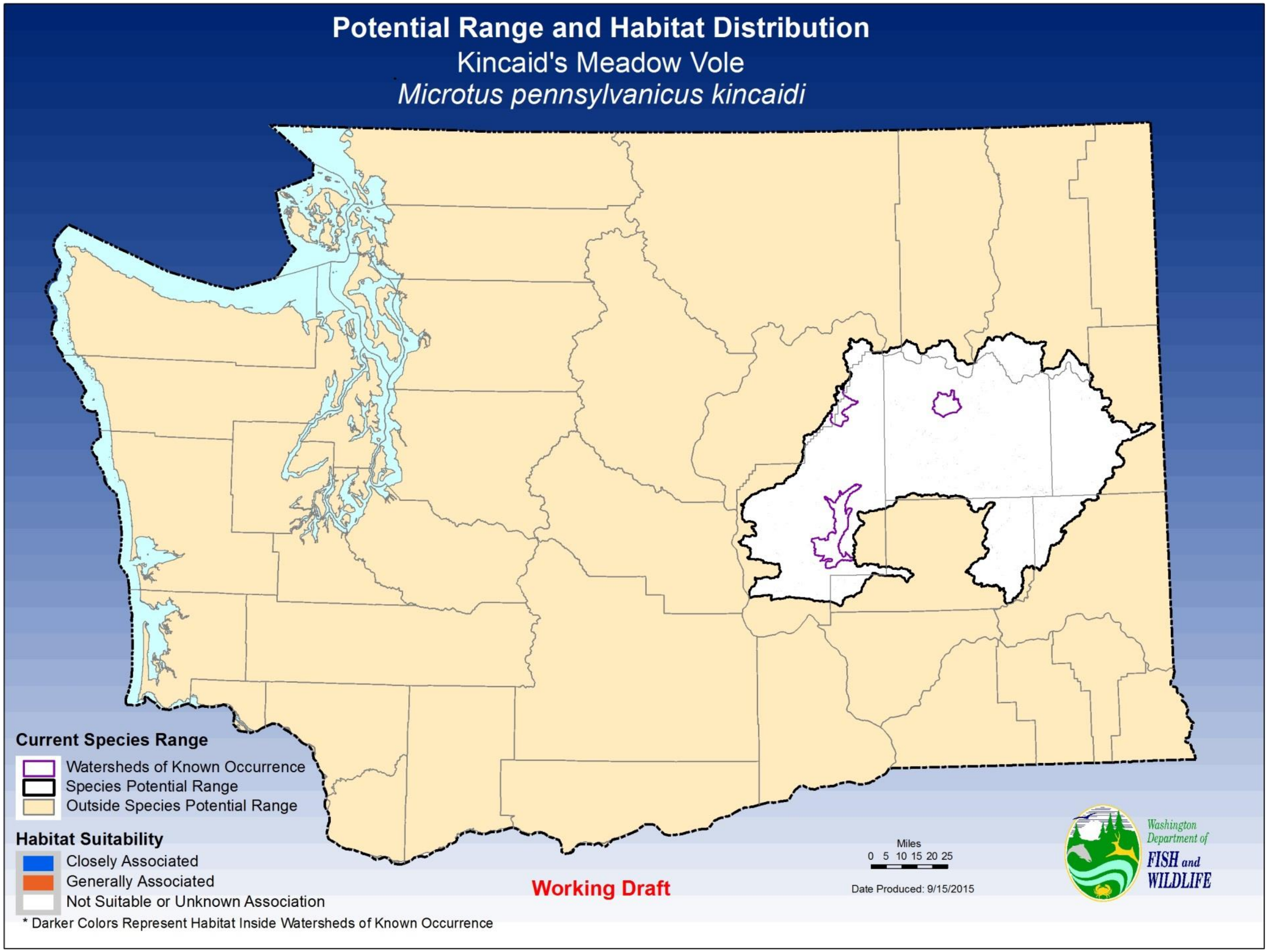
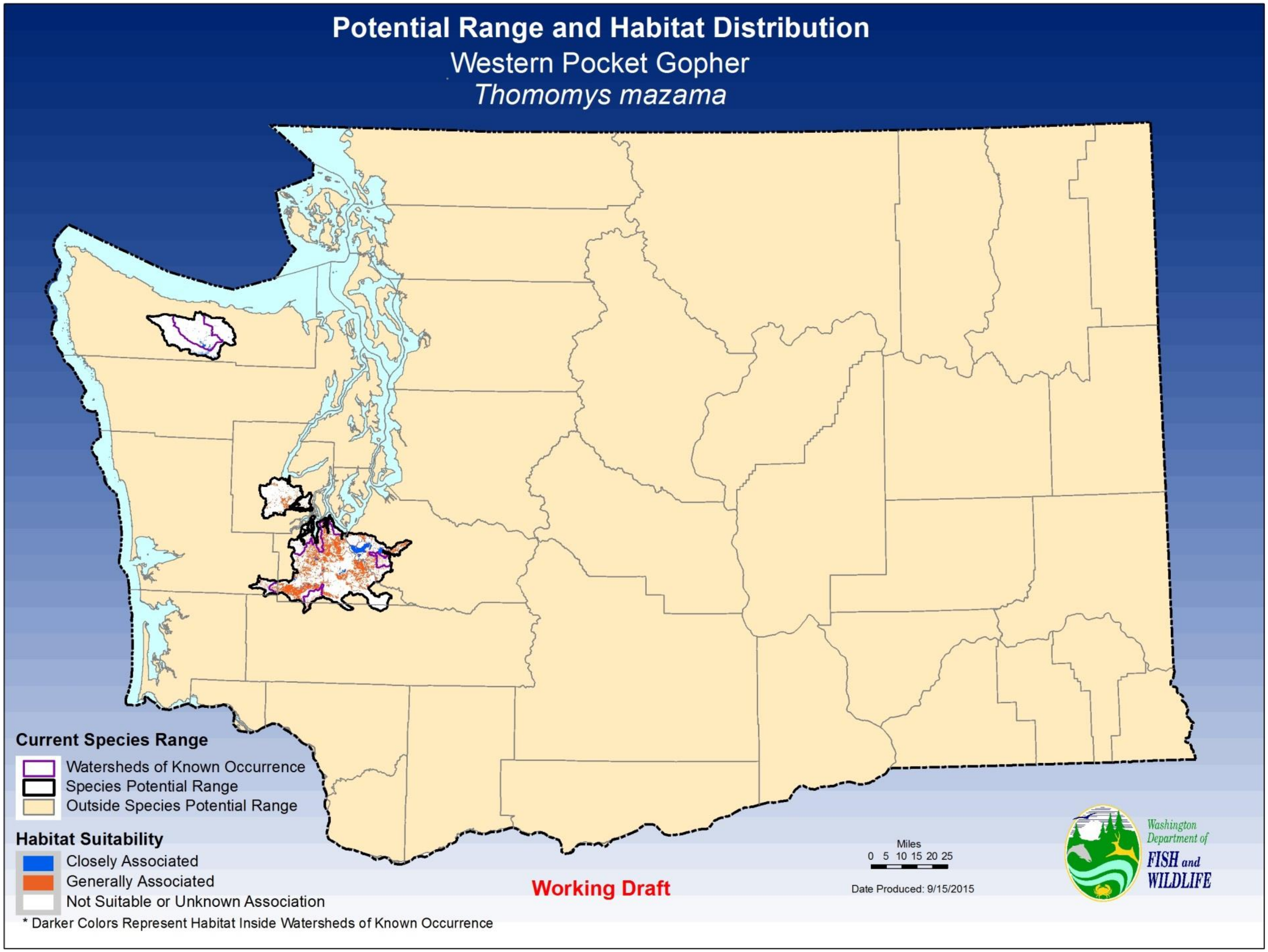
Date Produced: 9/15/2015
Washington Department of FISH and WILDLIFE

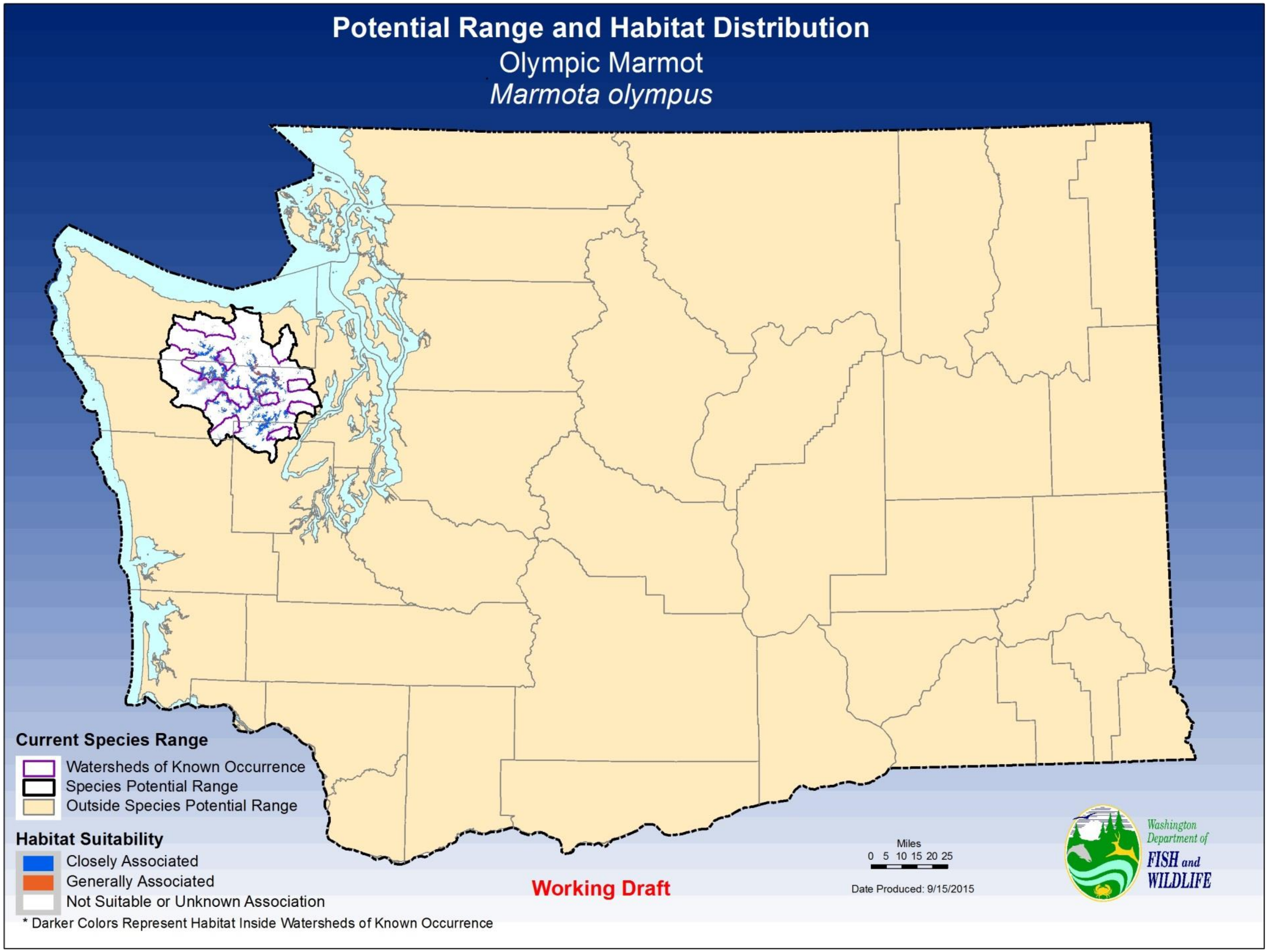
Kincaid's Meadow Vole



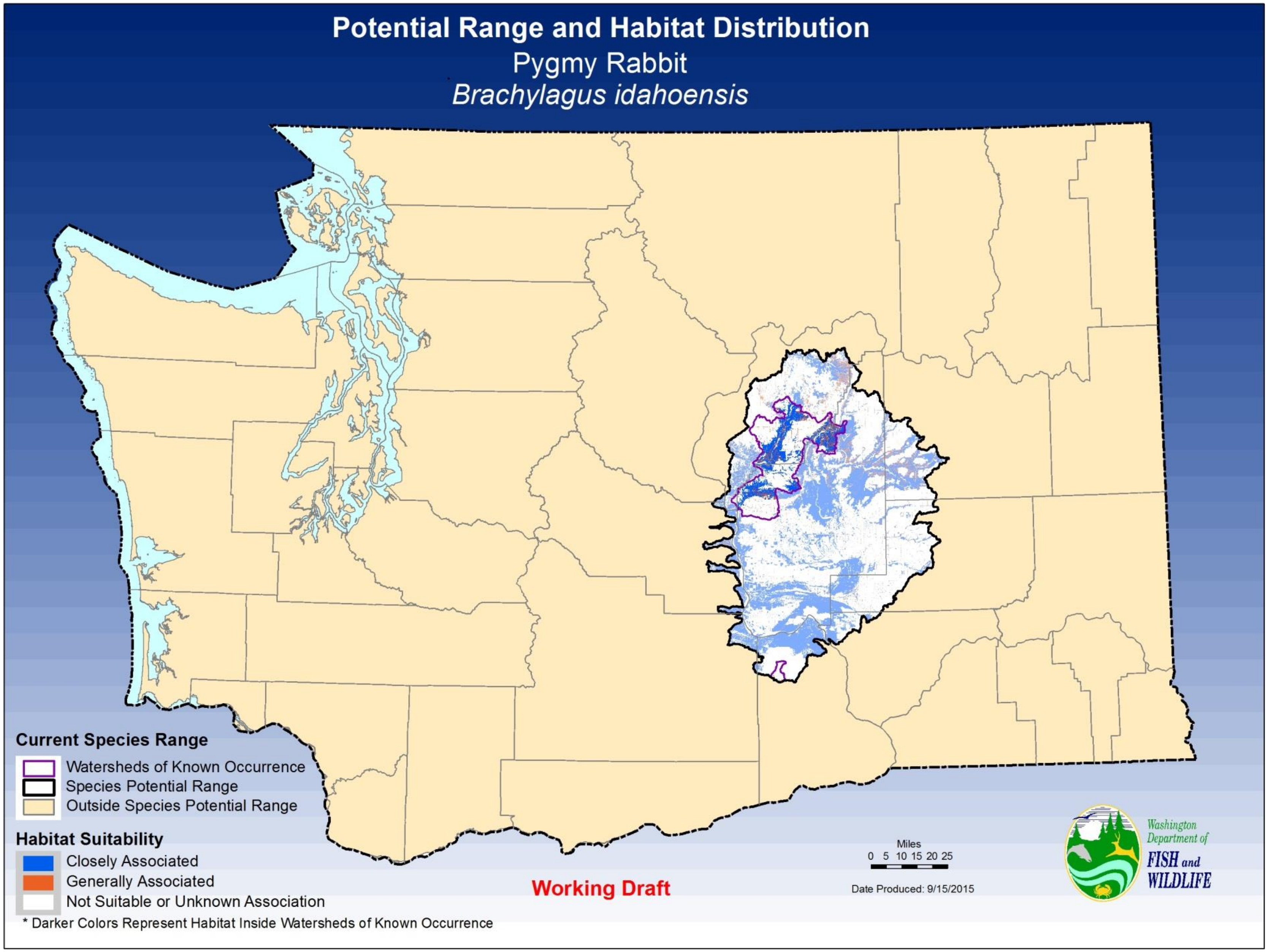
Mazama Pocket Gopher



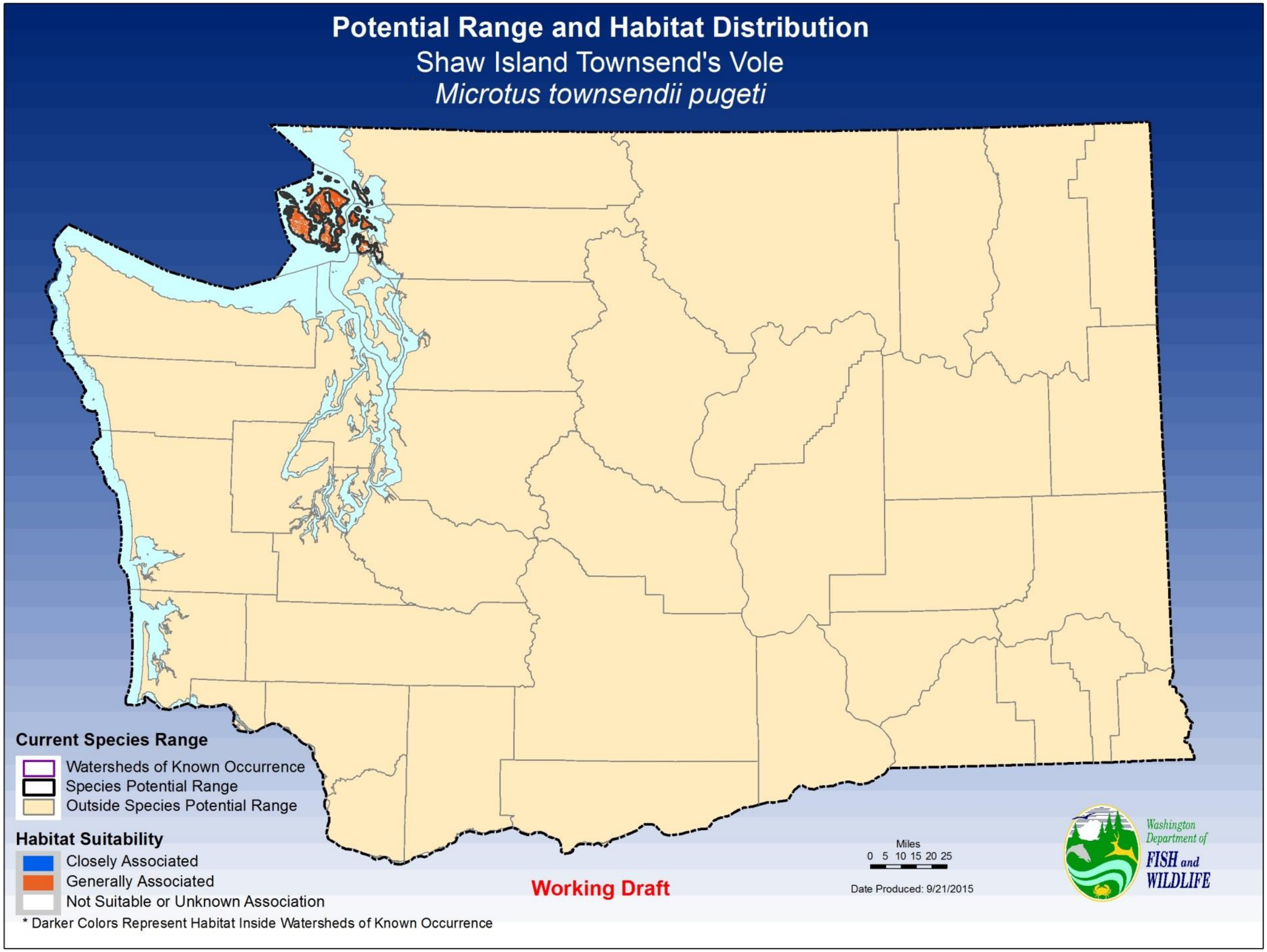
Olympic Marmot



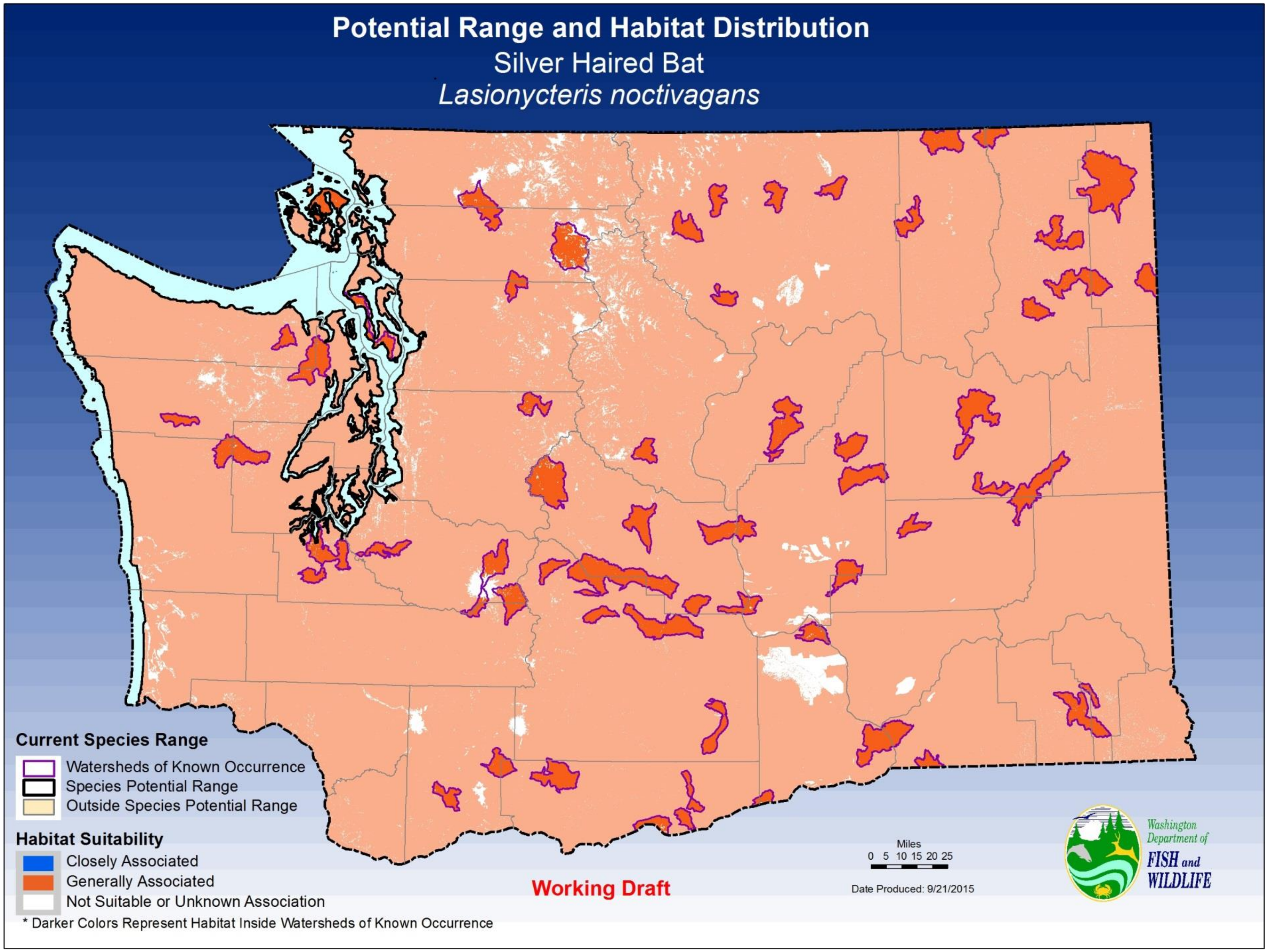
Pygmy Rabbit



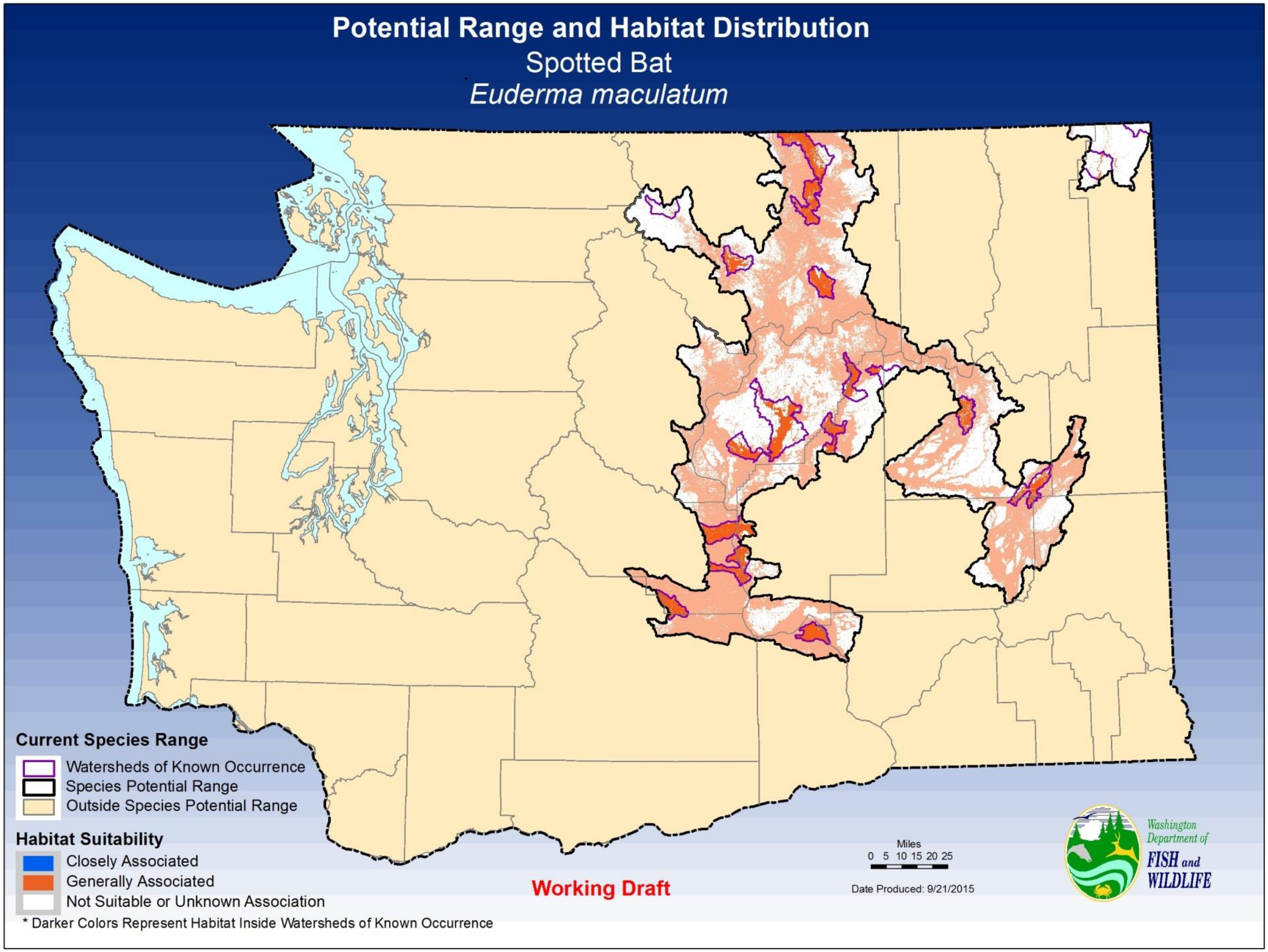
Shaw Island Townsend's Vole



Silver Haired Bat



Spotted Bat


Potential Range and Habitat Distribution
Spotted Bat
Euderma maculatum
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
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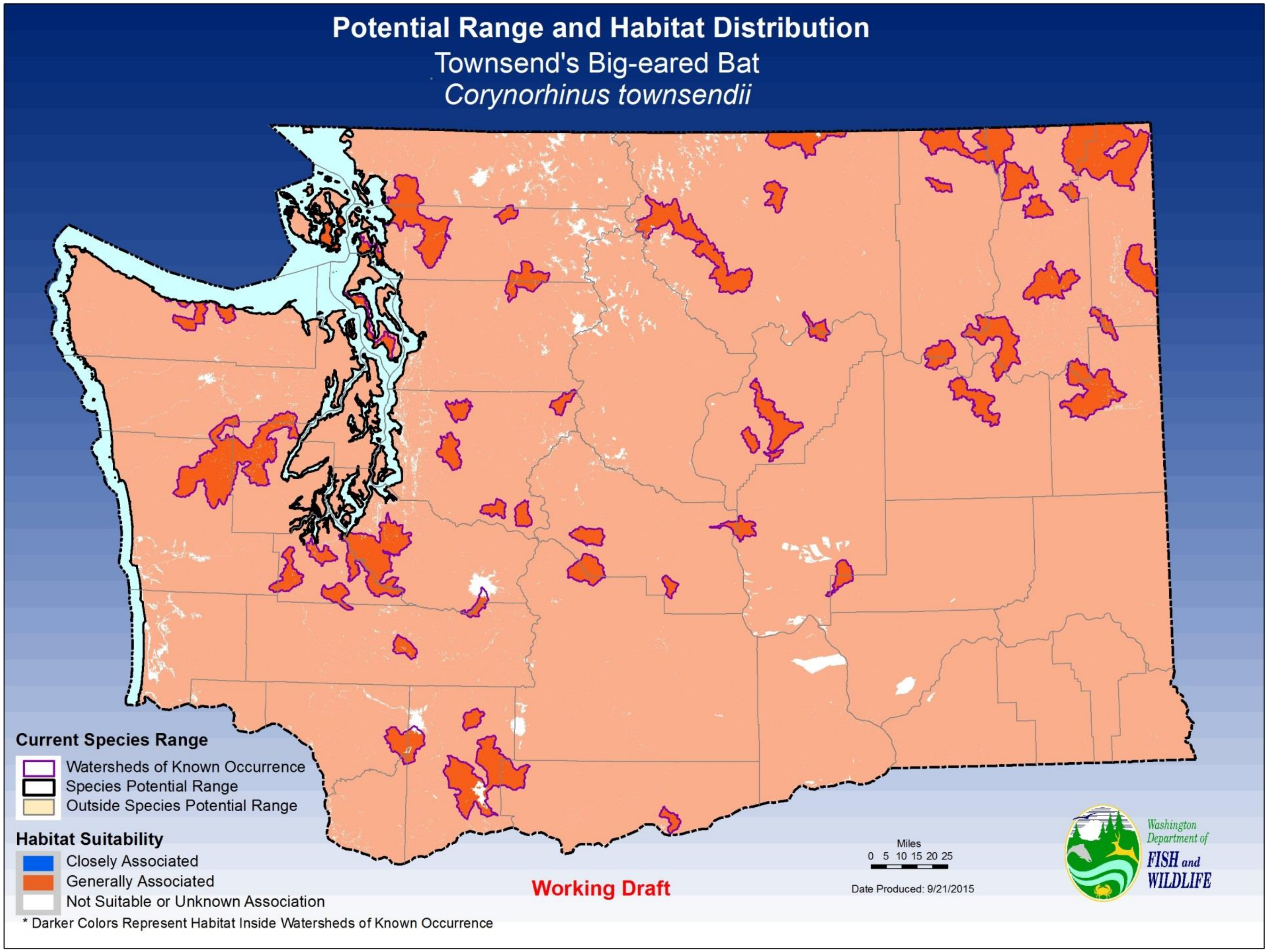
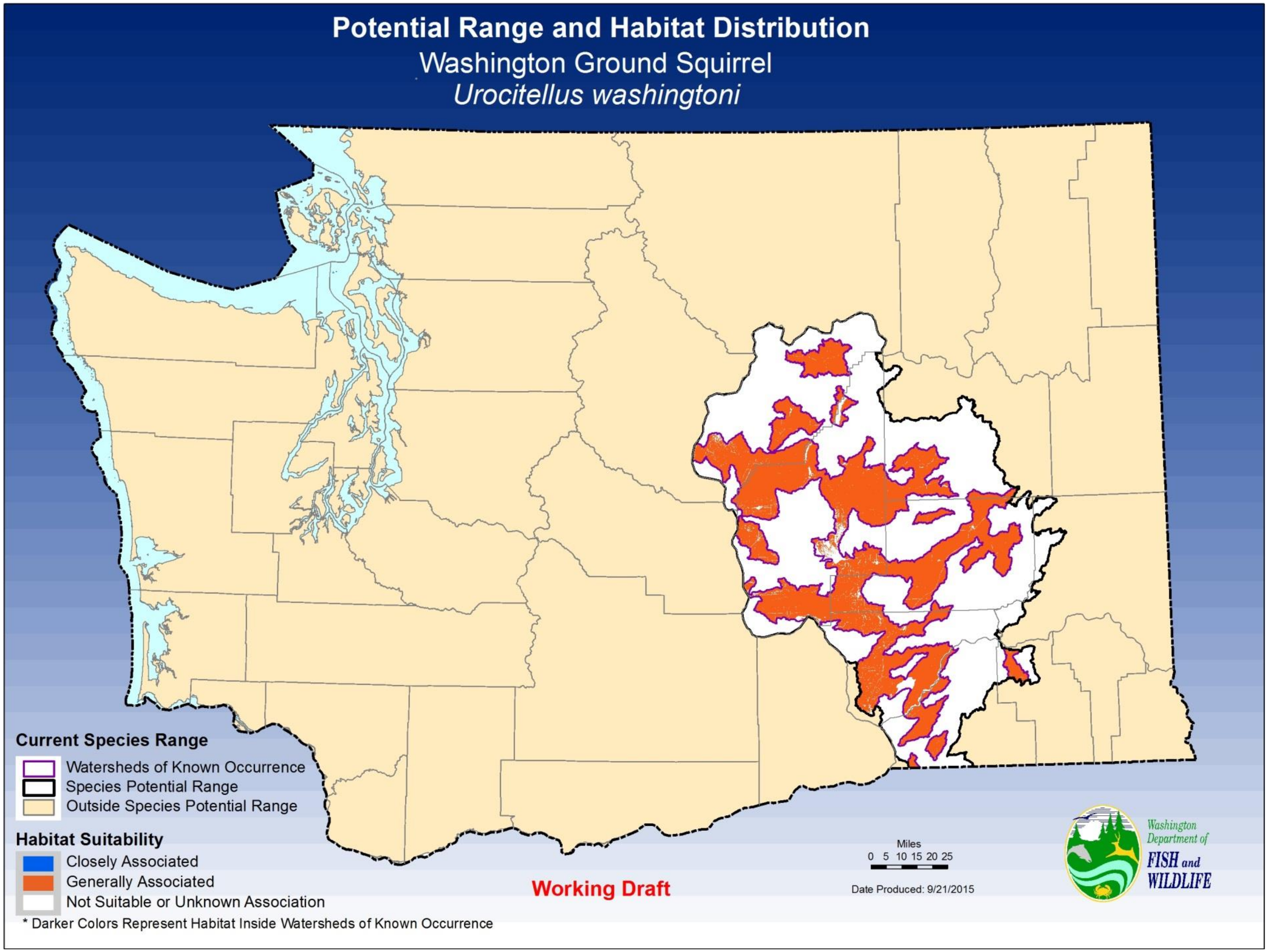
Date Produced: 9/21/2015
Washington Department of FISH and WILDLIFE

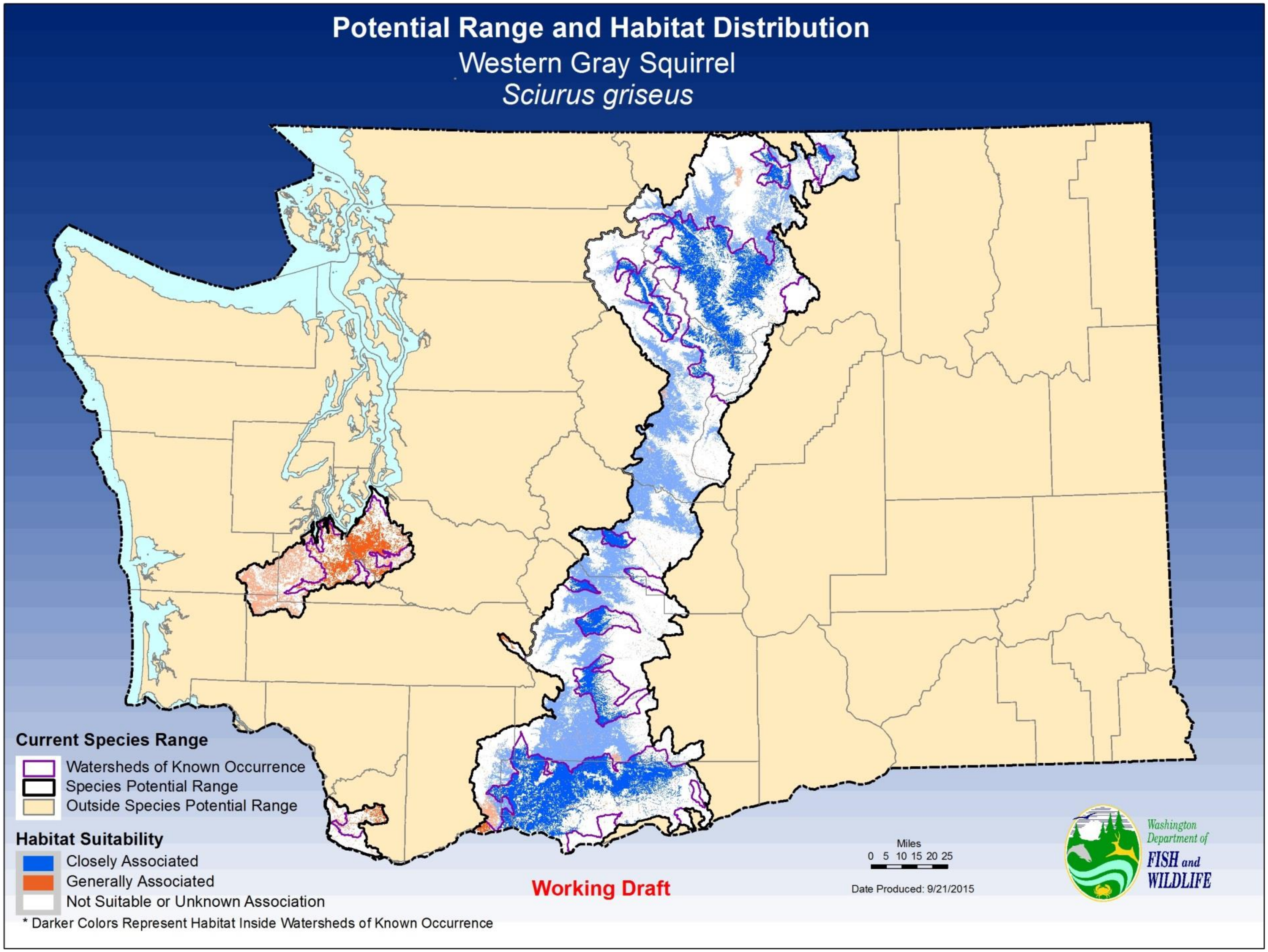
Townsend's Big-eared Bat



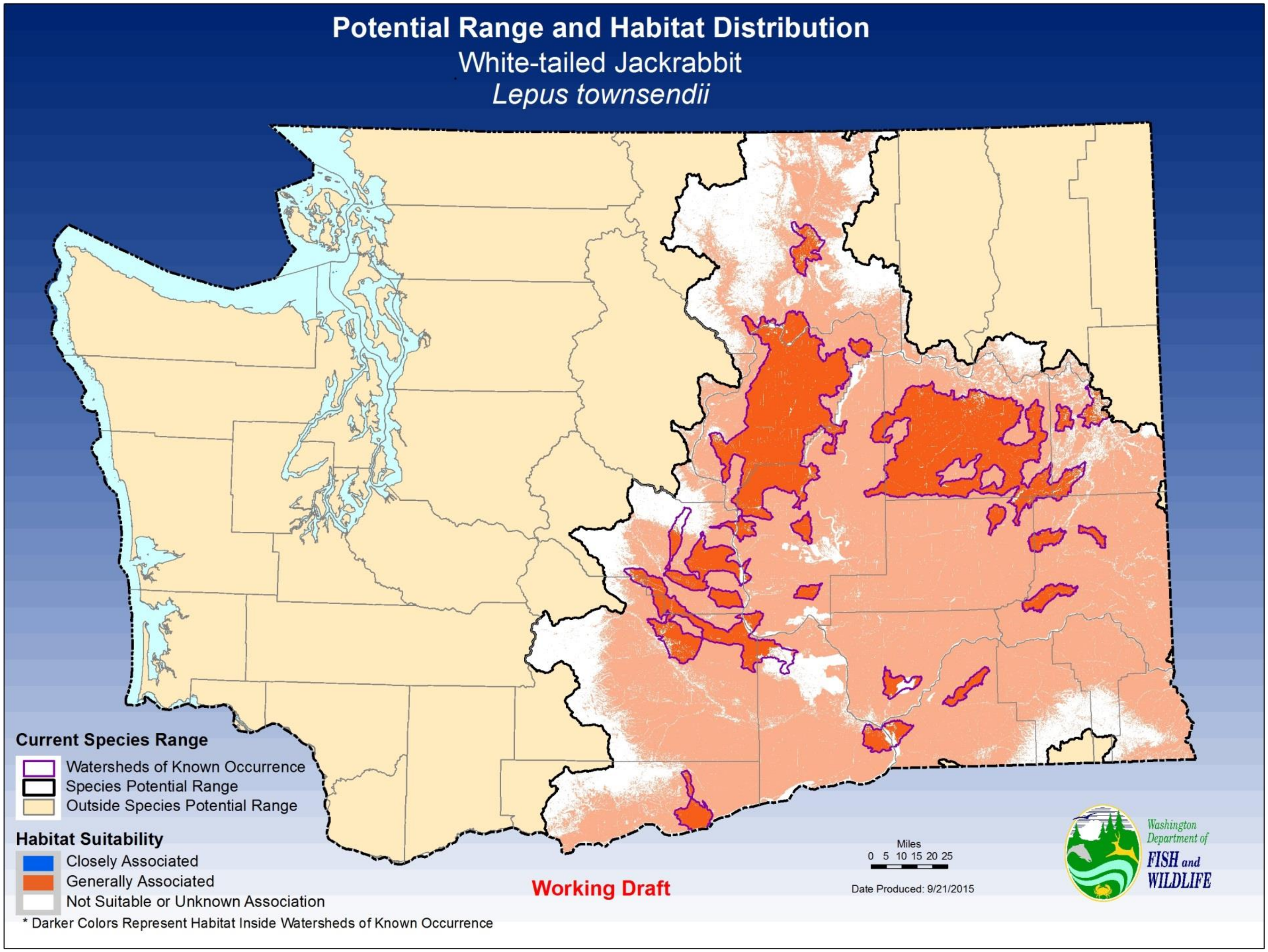
Washington Ground Squirrel



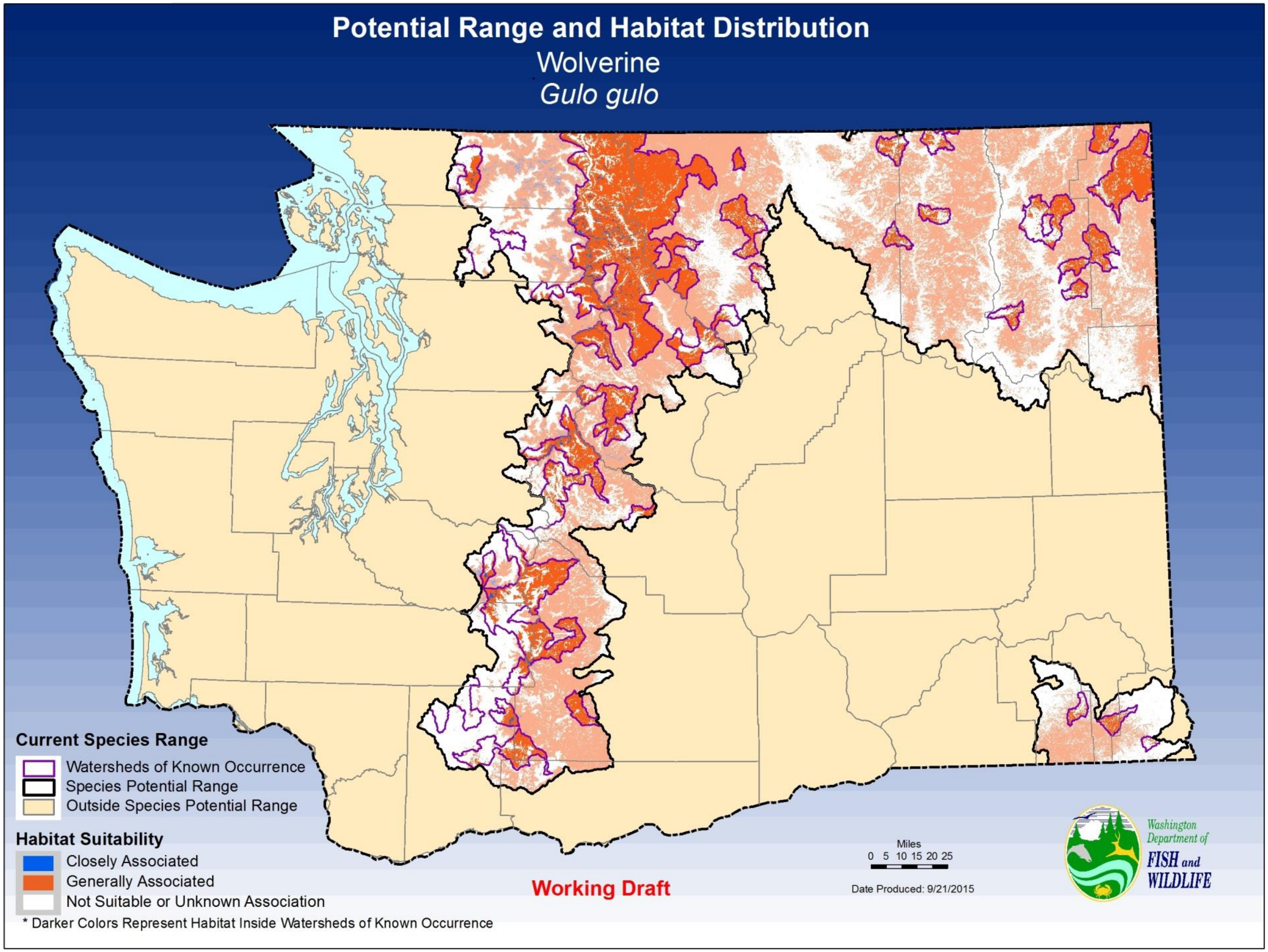
Western Gray Squirrel



White-tailed Jackrabbit



Wolverine


Potential Range and Habitat Distribution
Wolverine
Gulo gulo
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
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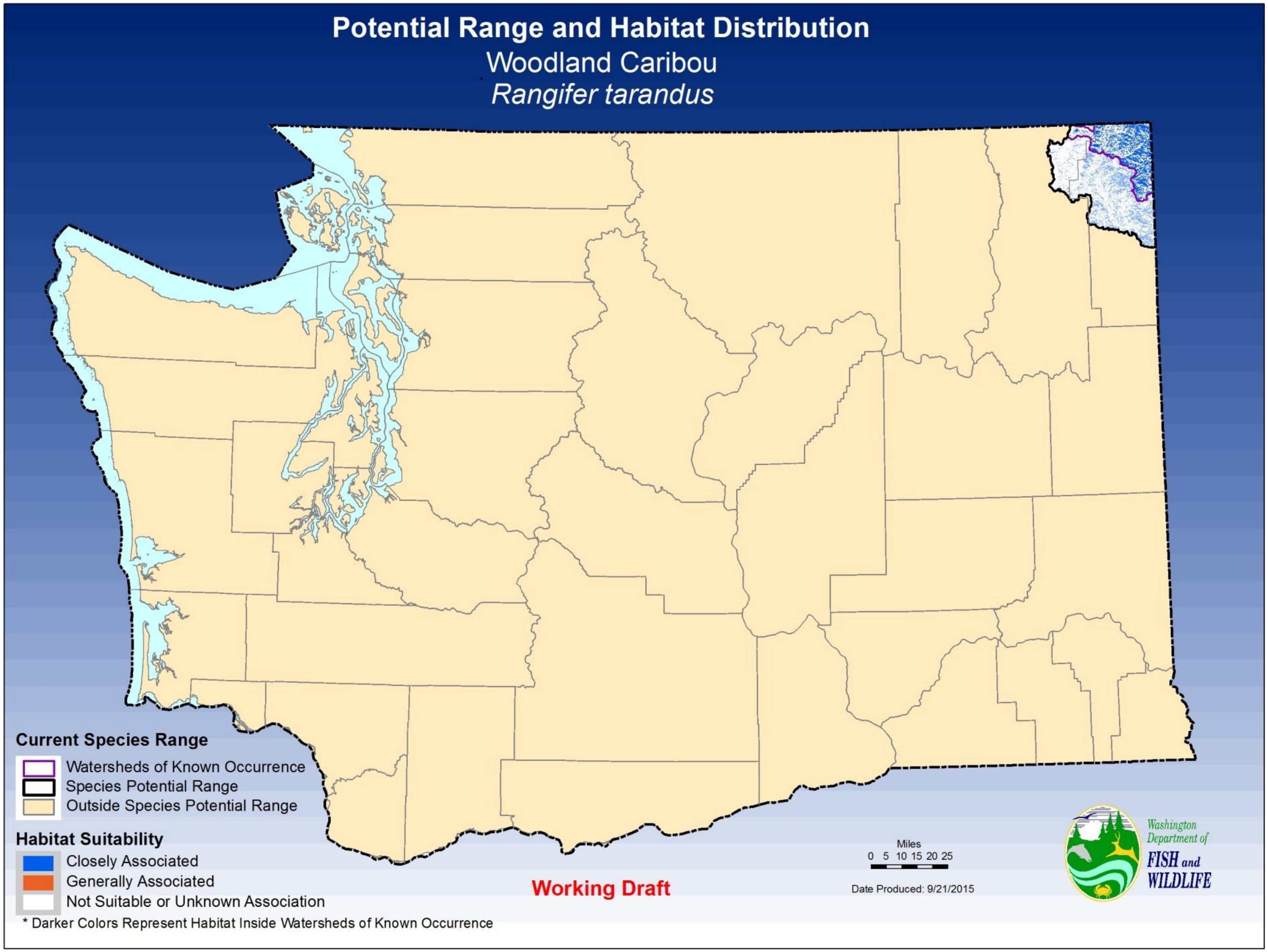
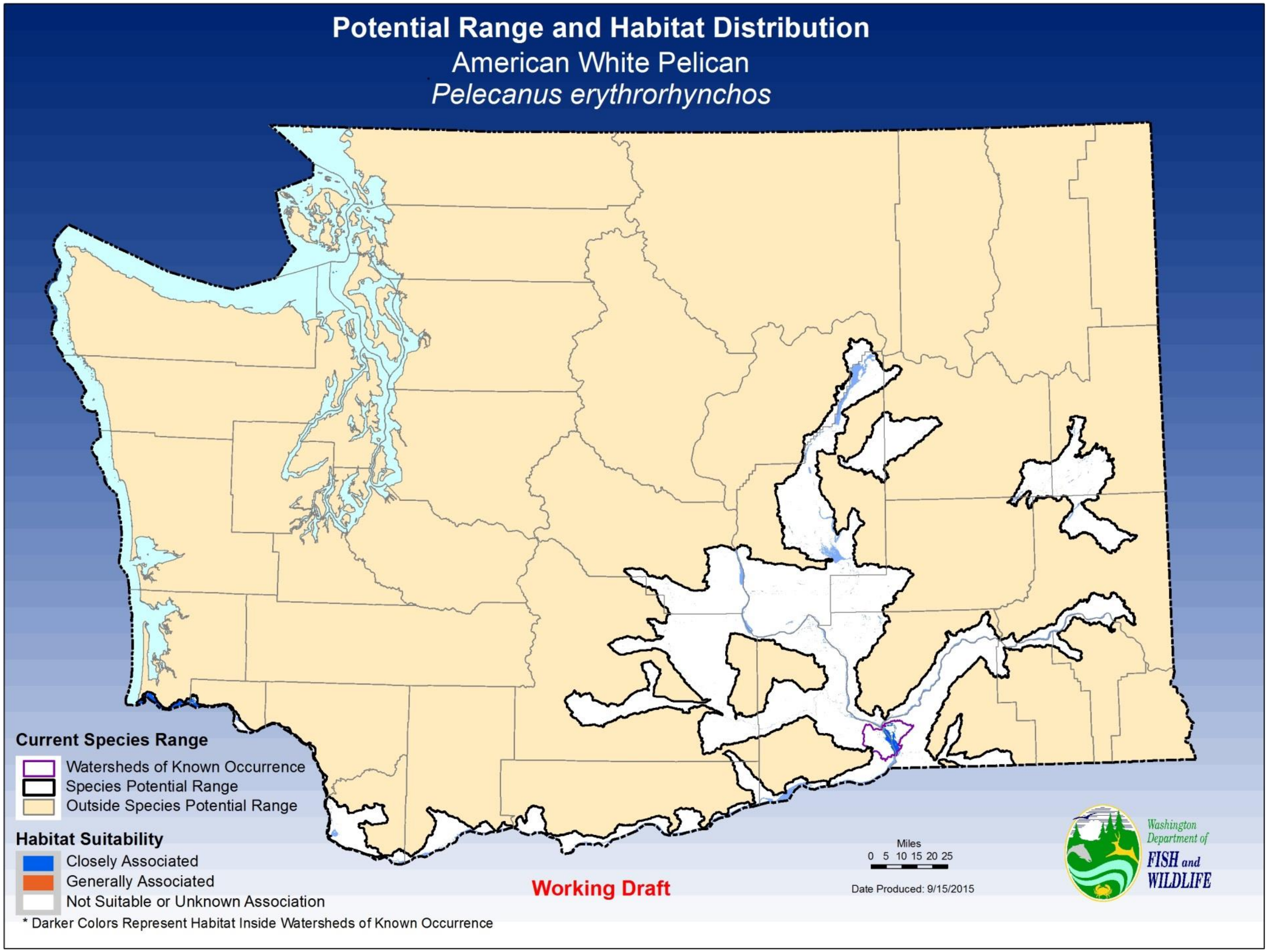
Date Produced: 9/21/2015
Washington Department of FISH and WILDLIFE

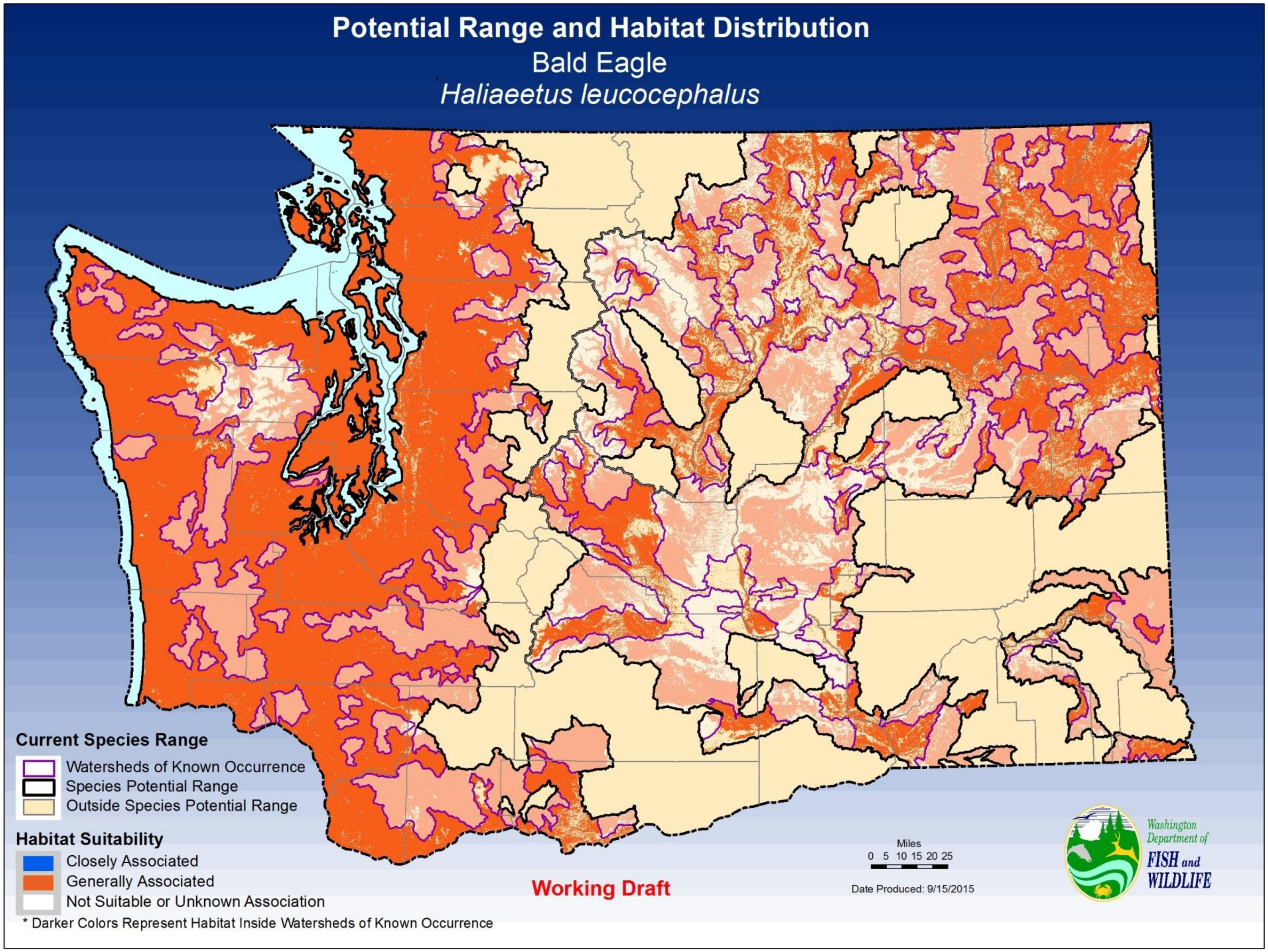
Woodland Caribou



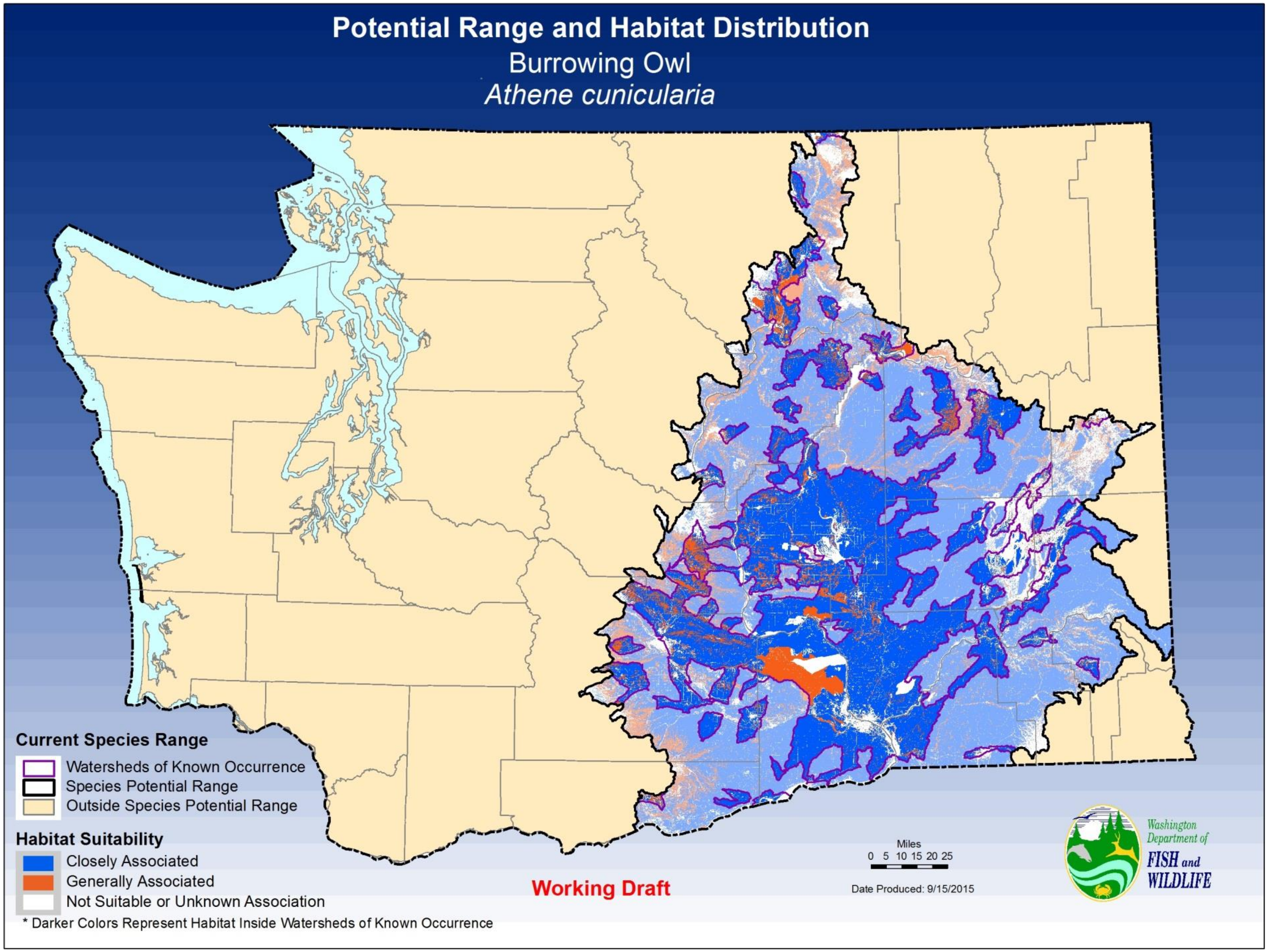
American White Pelican



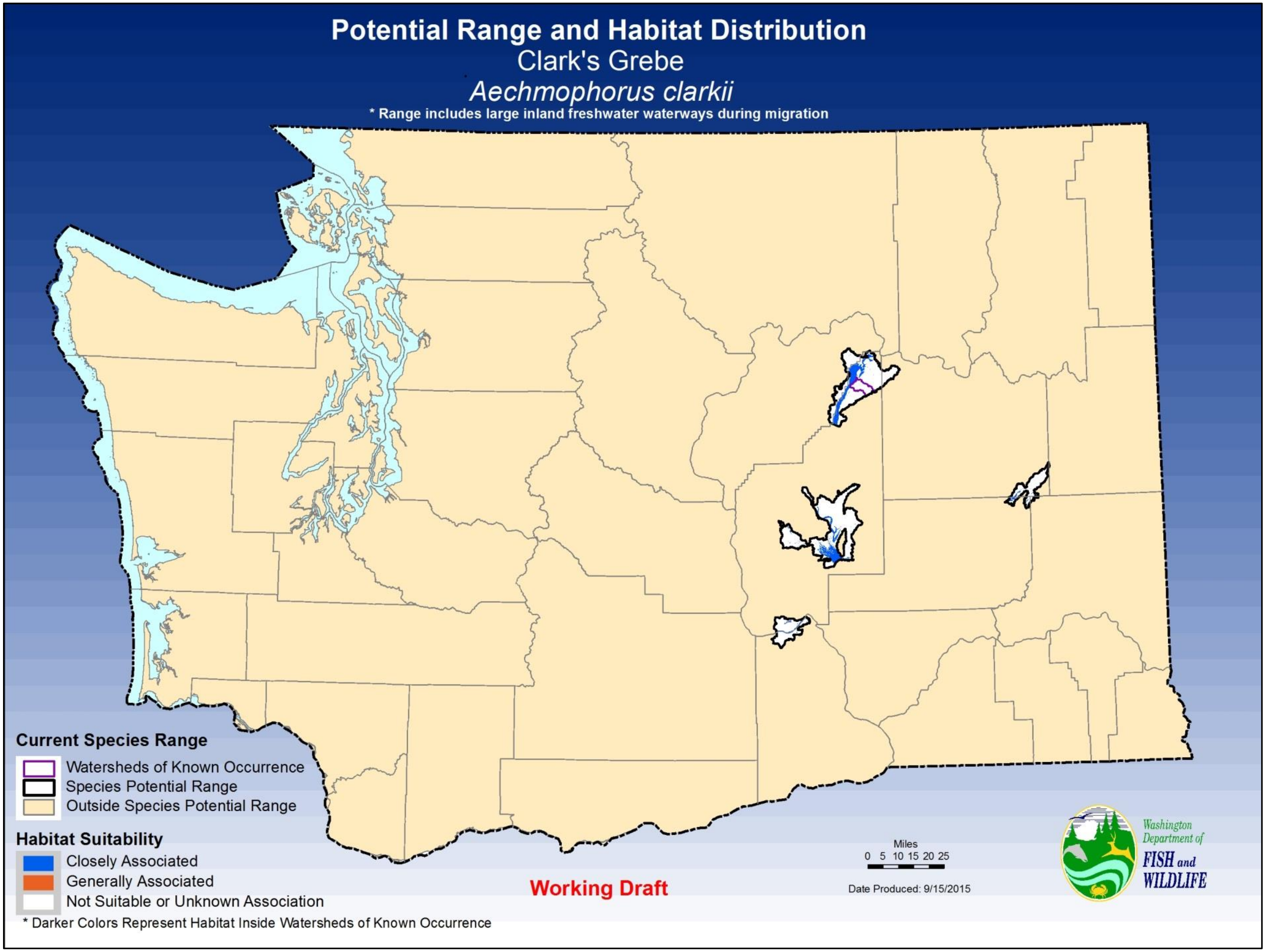
Bald Eagle


Potential Range and Habitat Distribution
Bald Eagle
Haliaeetus leucocephalus
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

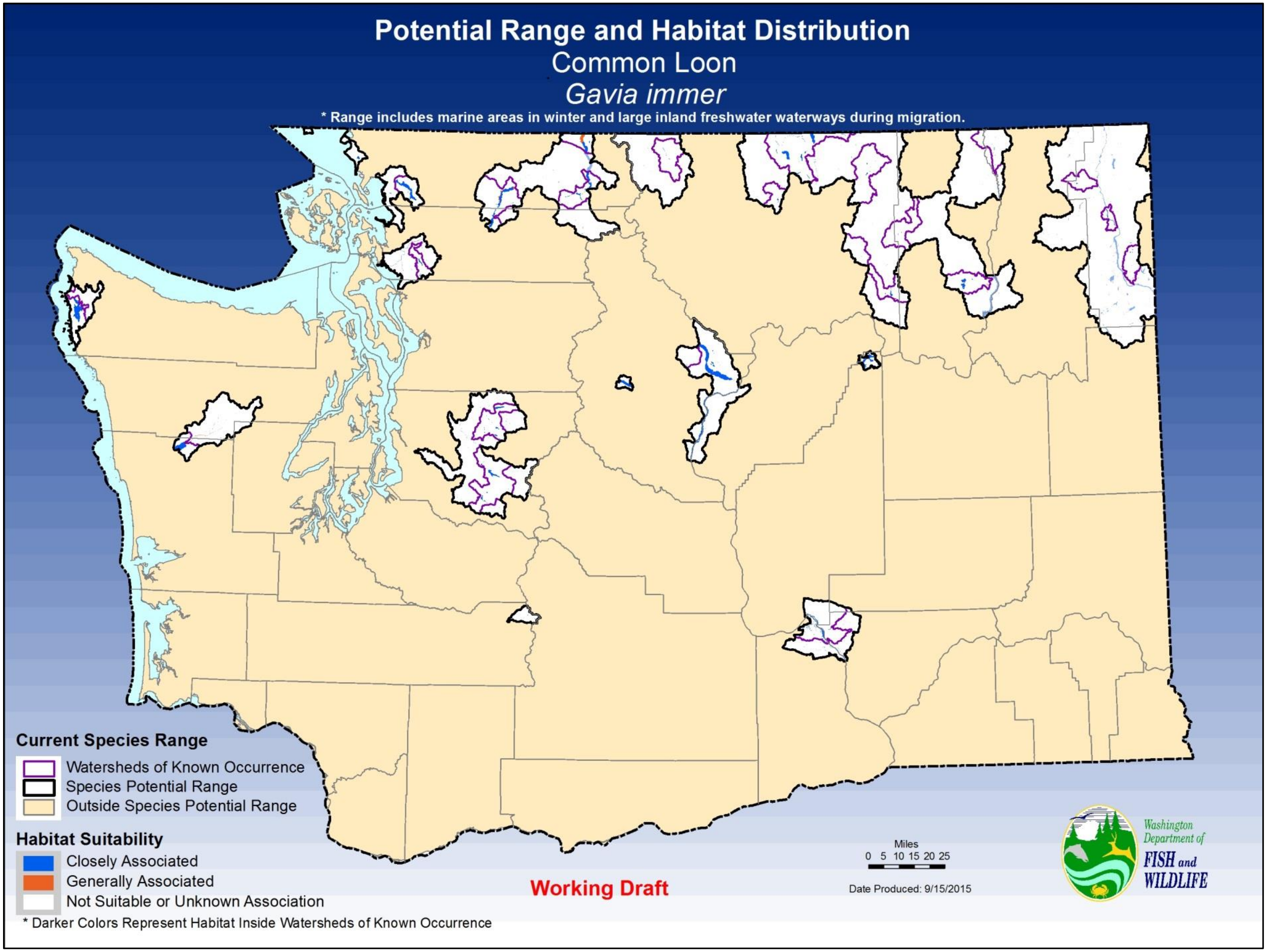
Burrowing Owl



Clark's Grebe

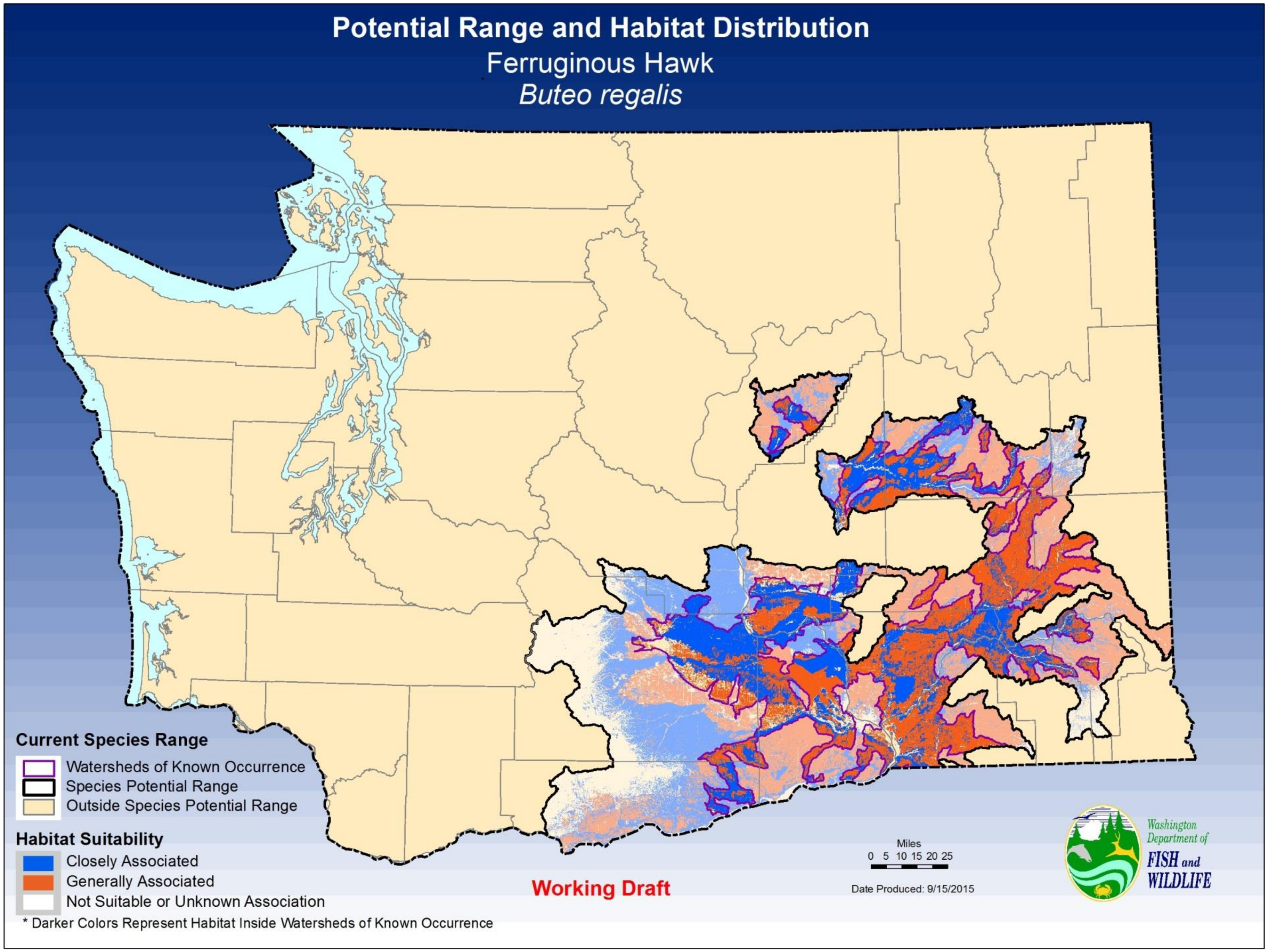


Common Loon

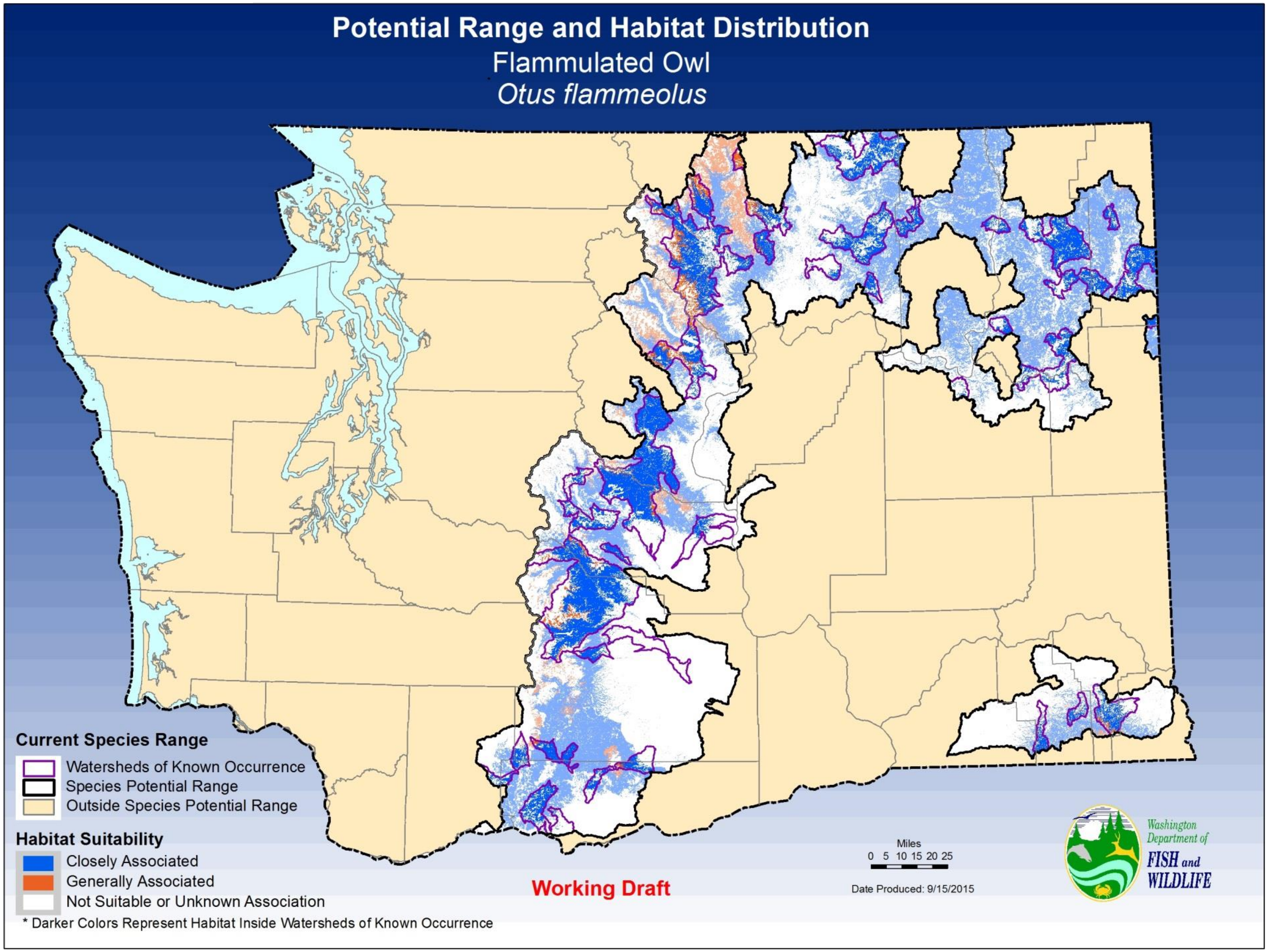


Potential Range and Habitat Distribution
Common Loon
Gavia immer
* Range includes marine areas in winter and large inland freshwater waterways during migration.
Current Species Range
Watersheds of Known Occurrence
Species Potential Range
Outside Species Potential Range
Habitat Suitability
Closely Associated
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

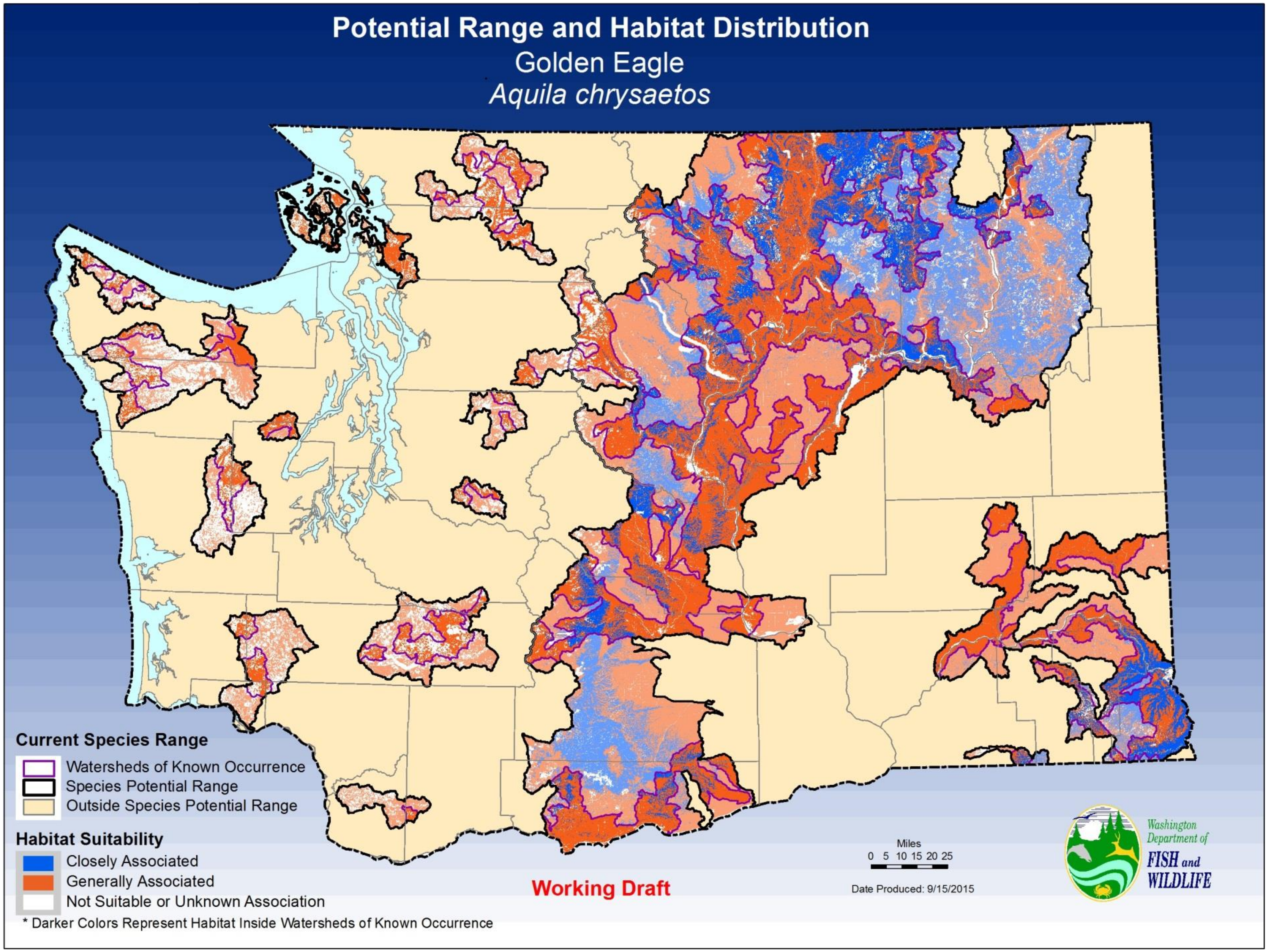
Ferruginous Hawk



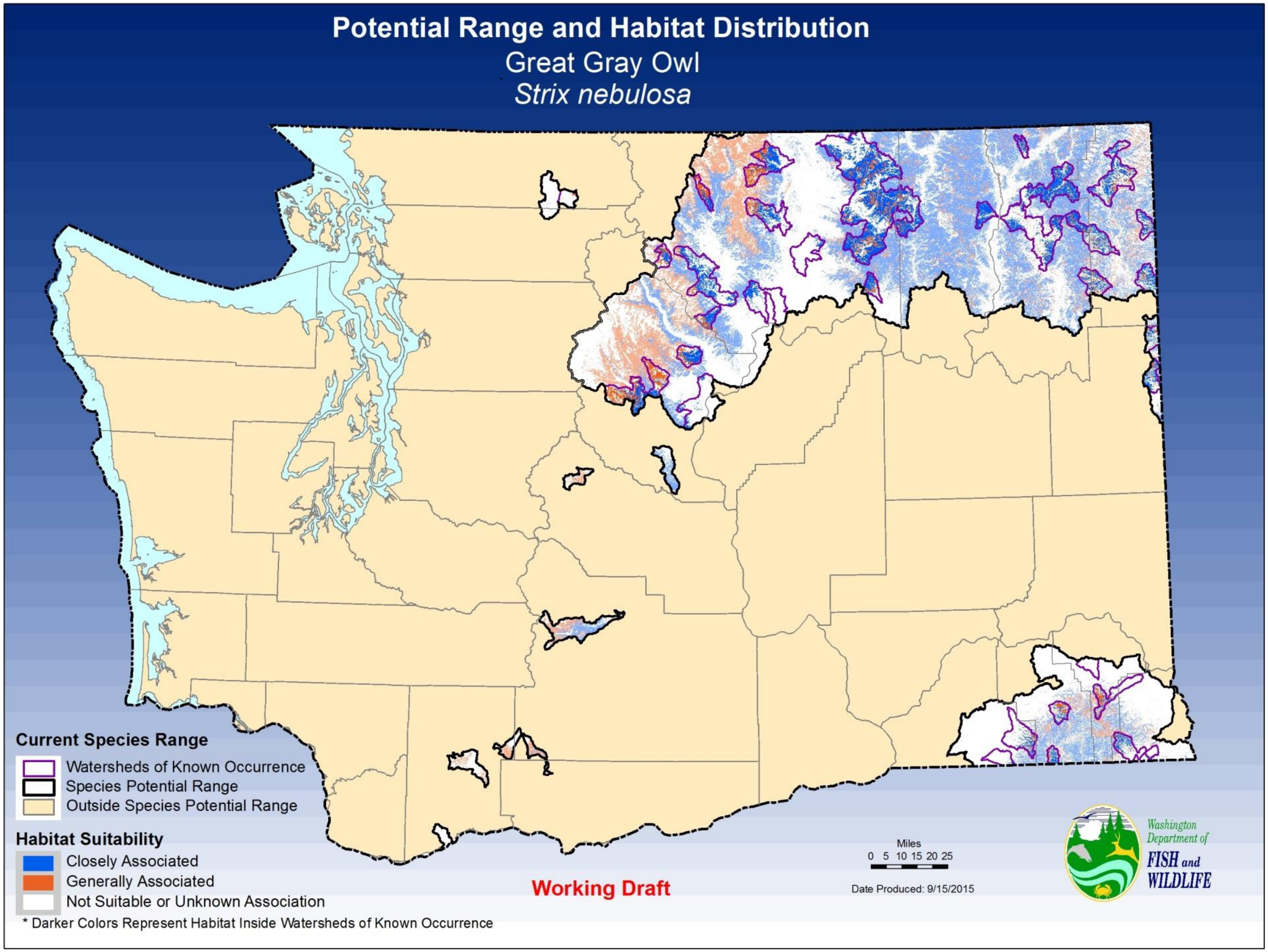
Flammulated Owl



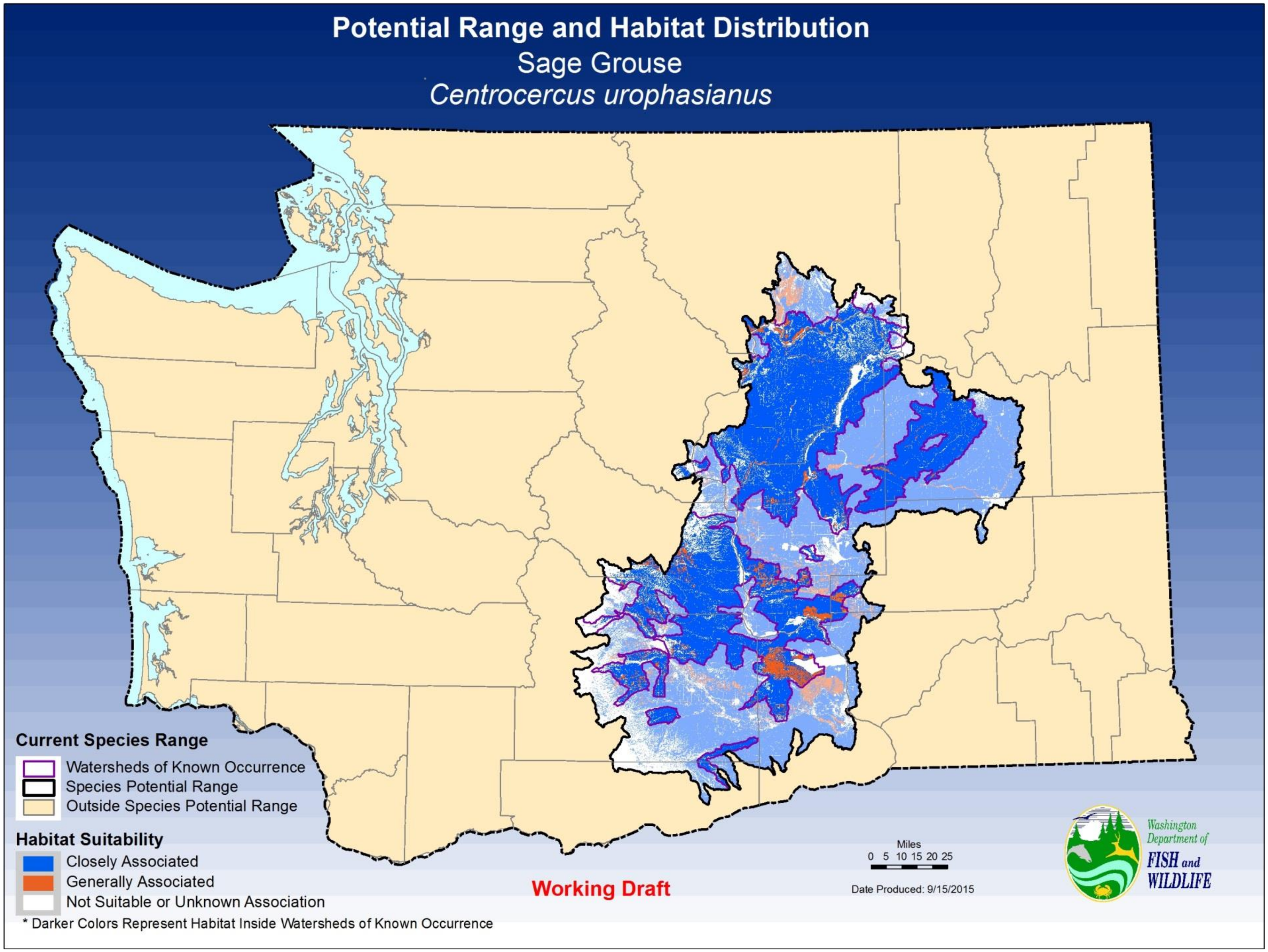
Golden Eagle



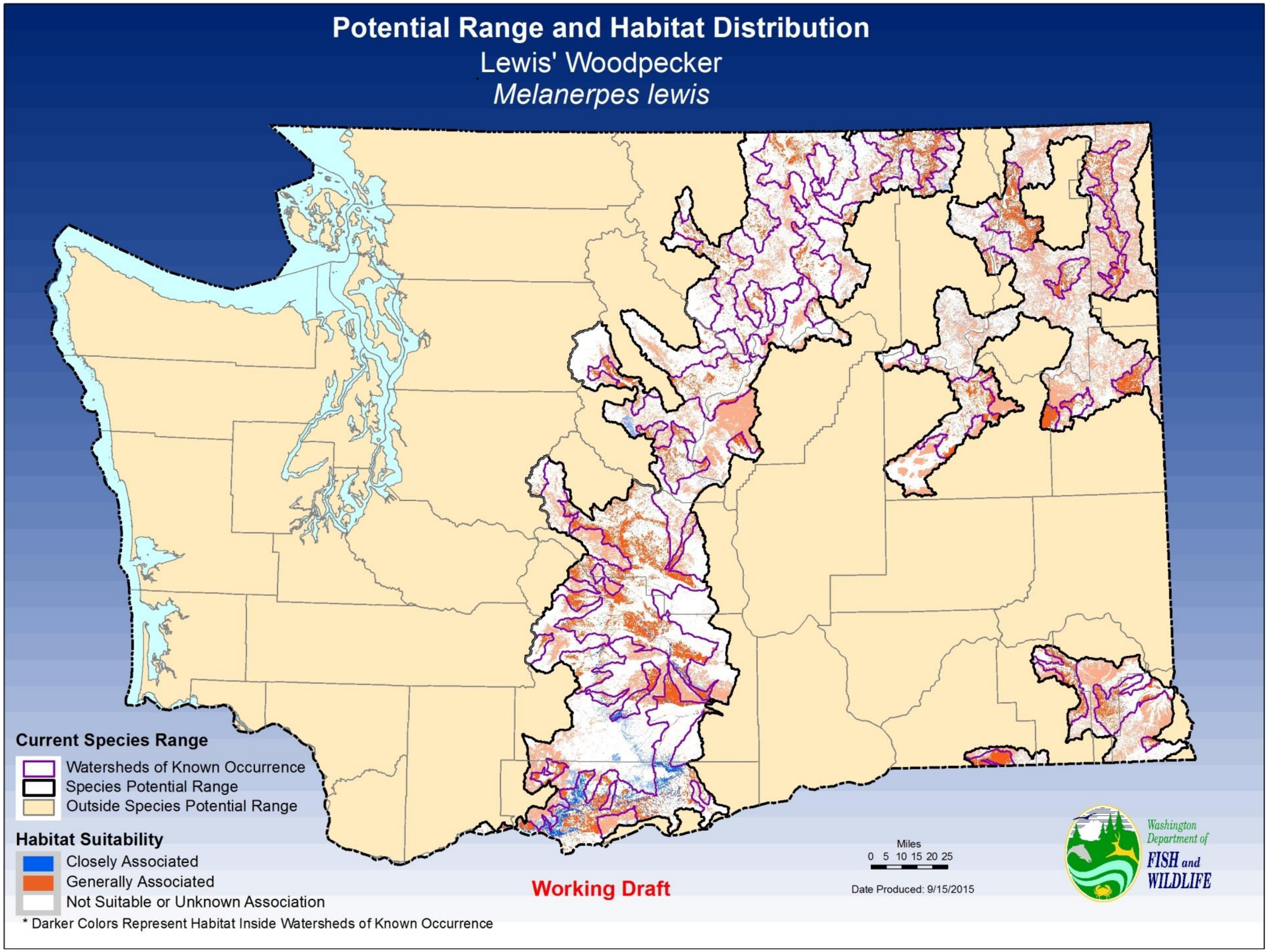
Great Gray Owl



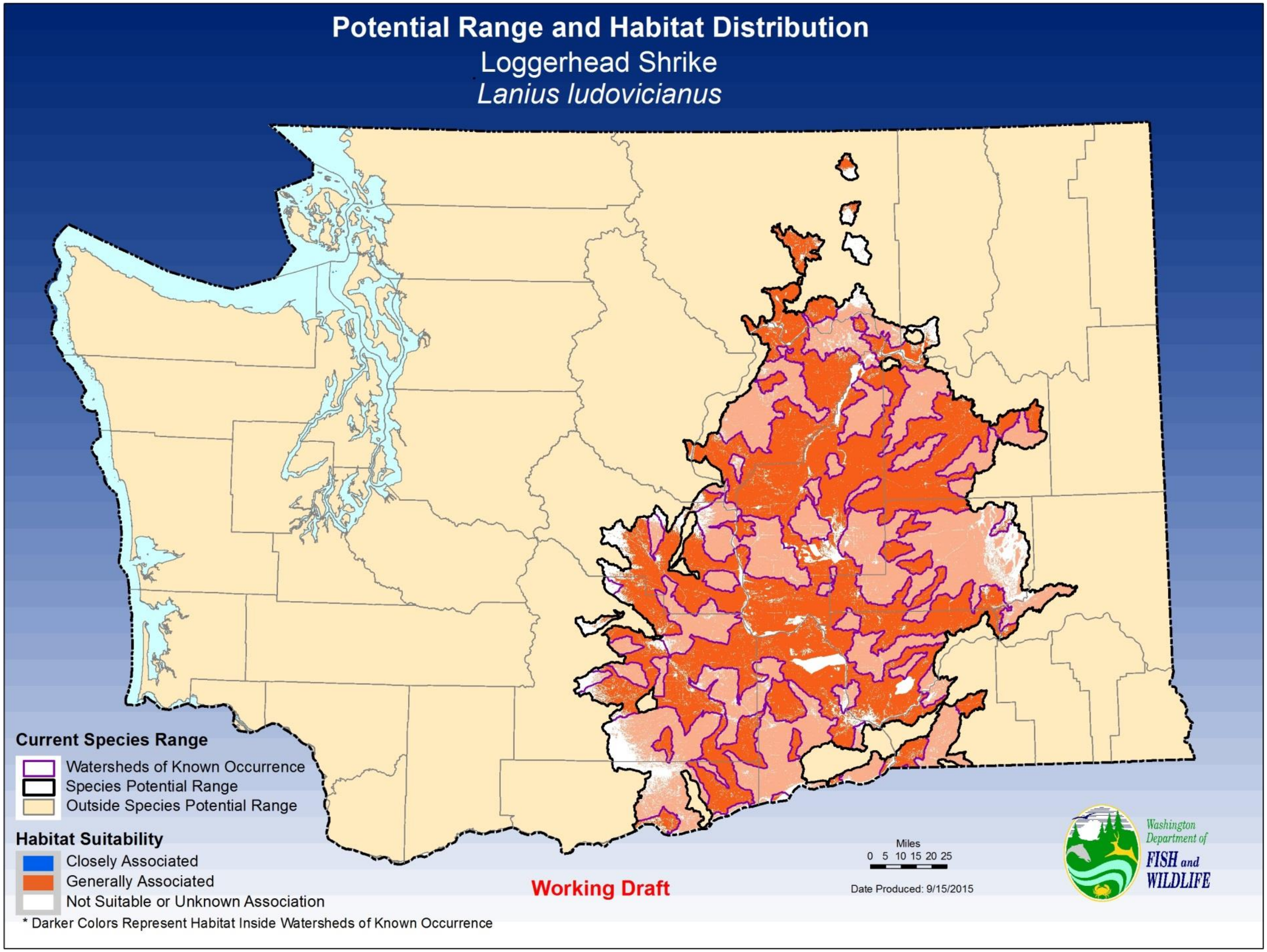
Greater Sage Grouse



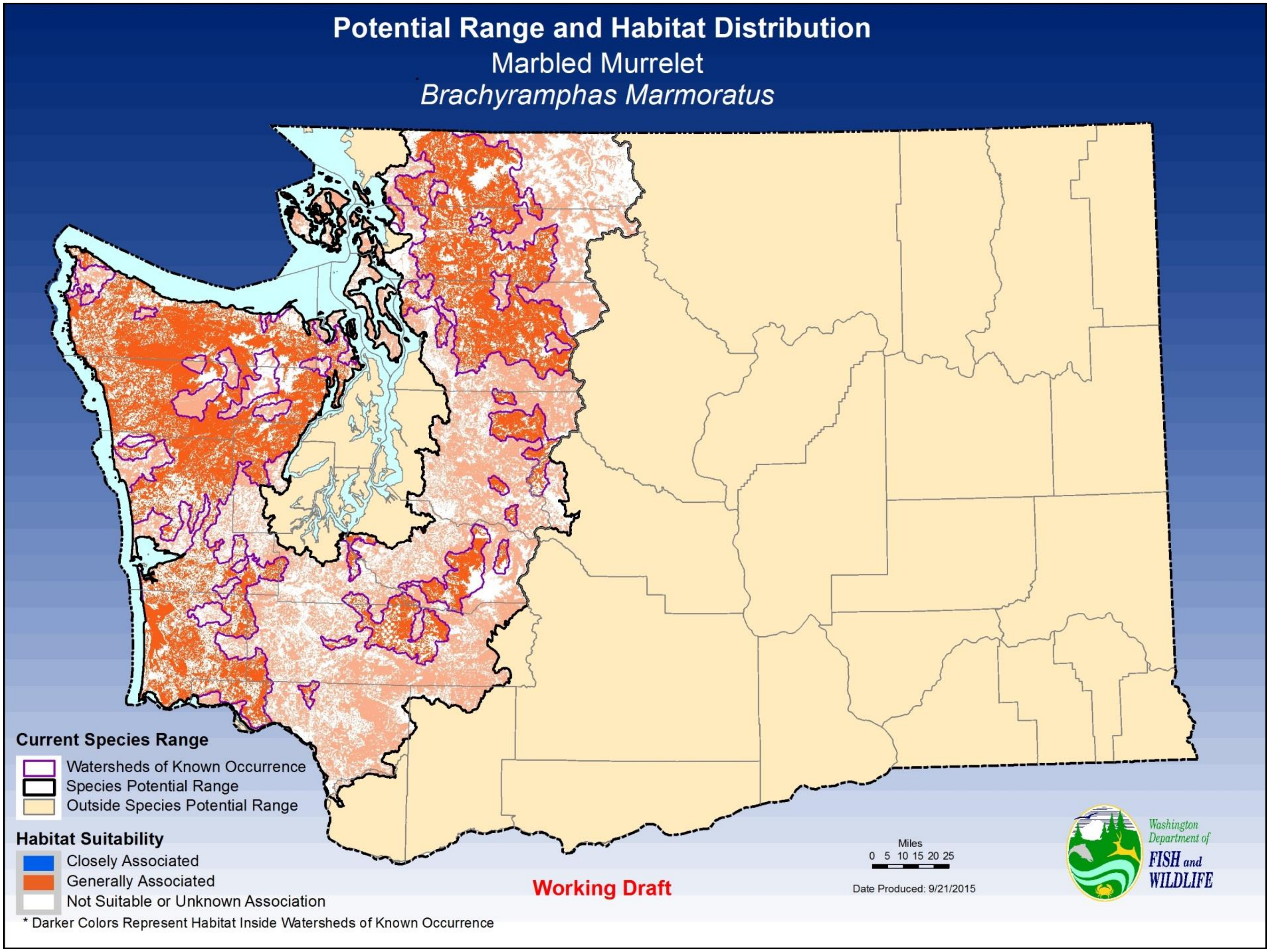
Lewis' Woodpecker



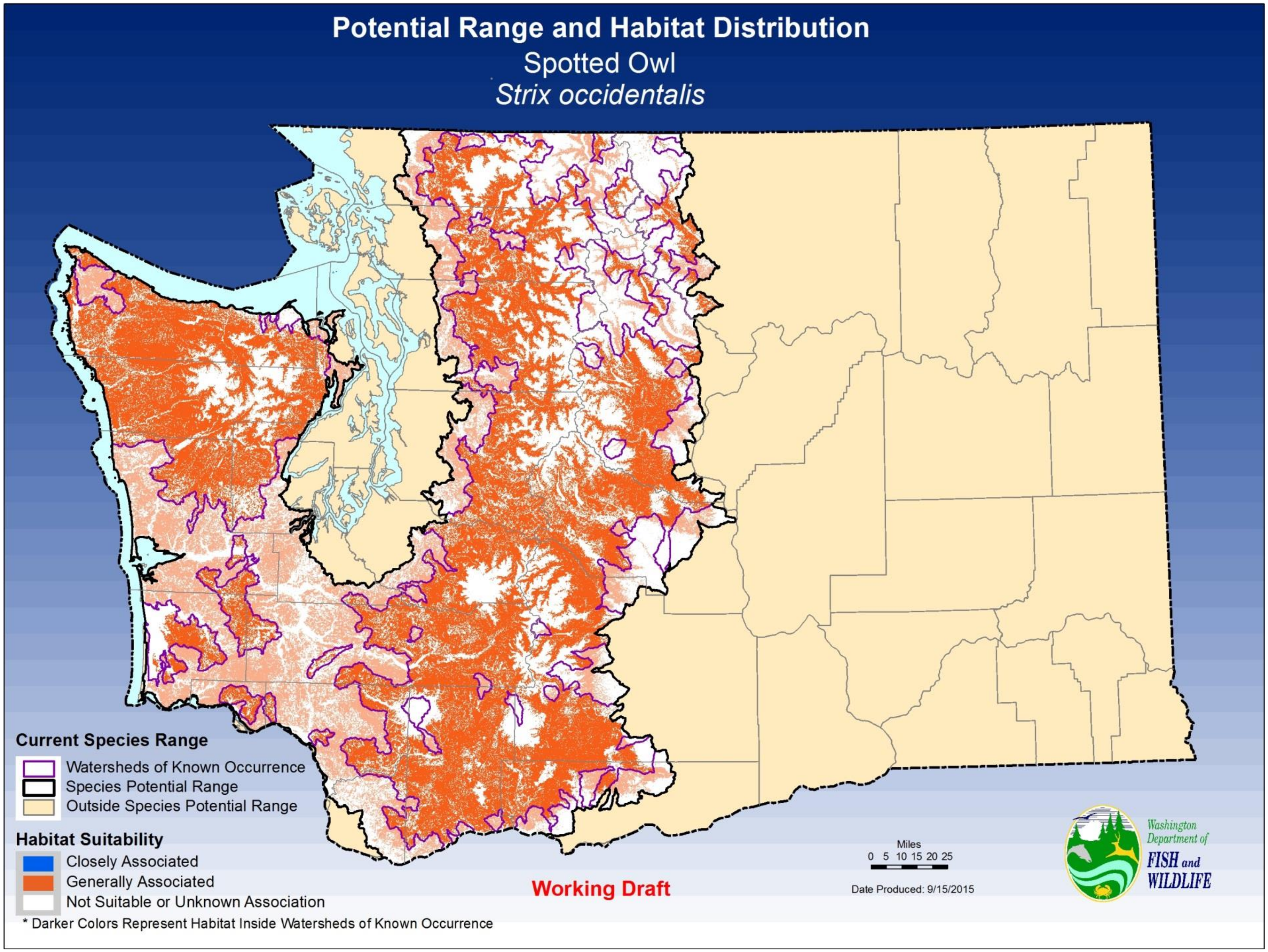
Loggerhead Shrike



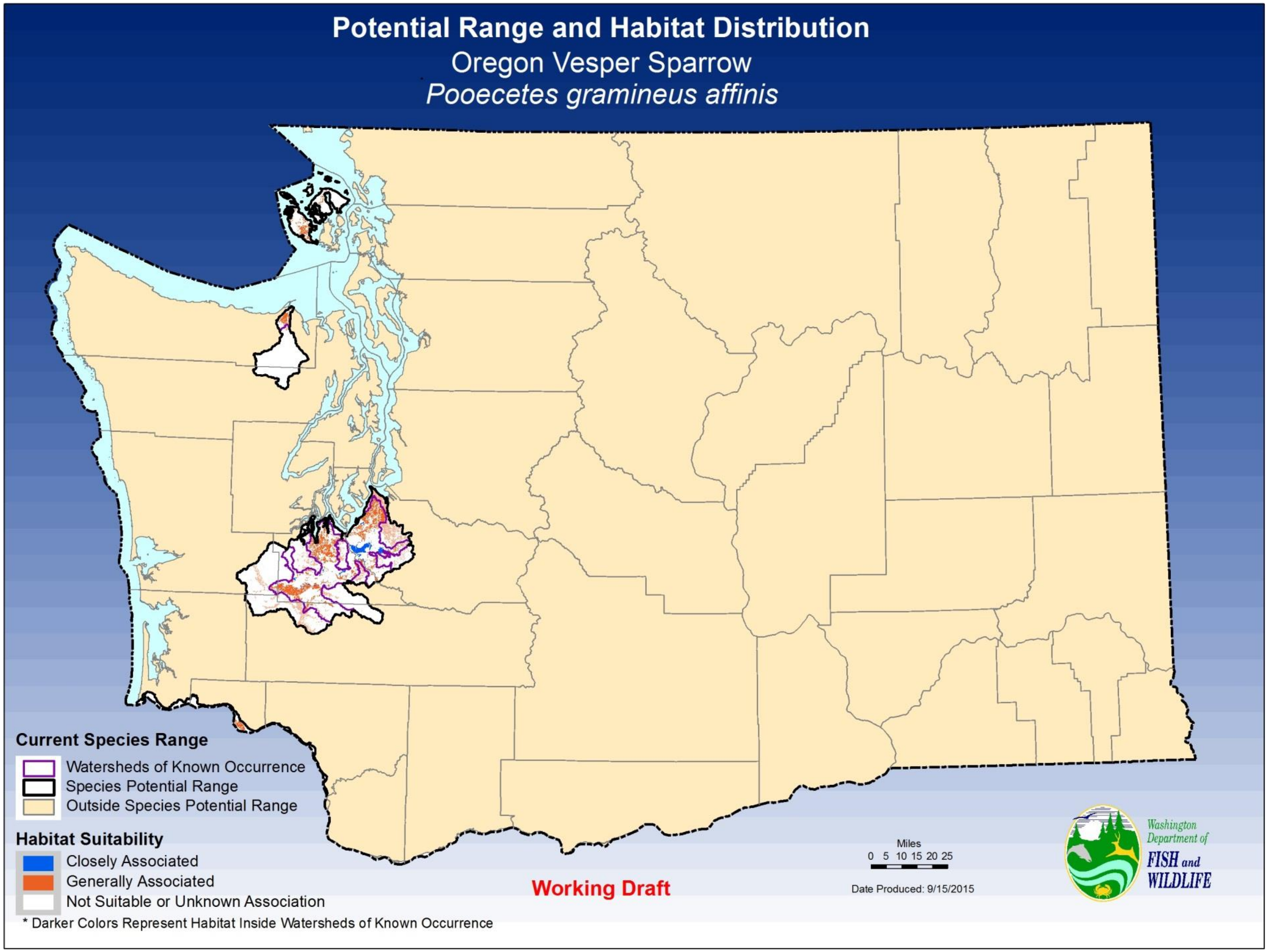
Marbled Murrelet



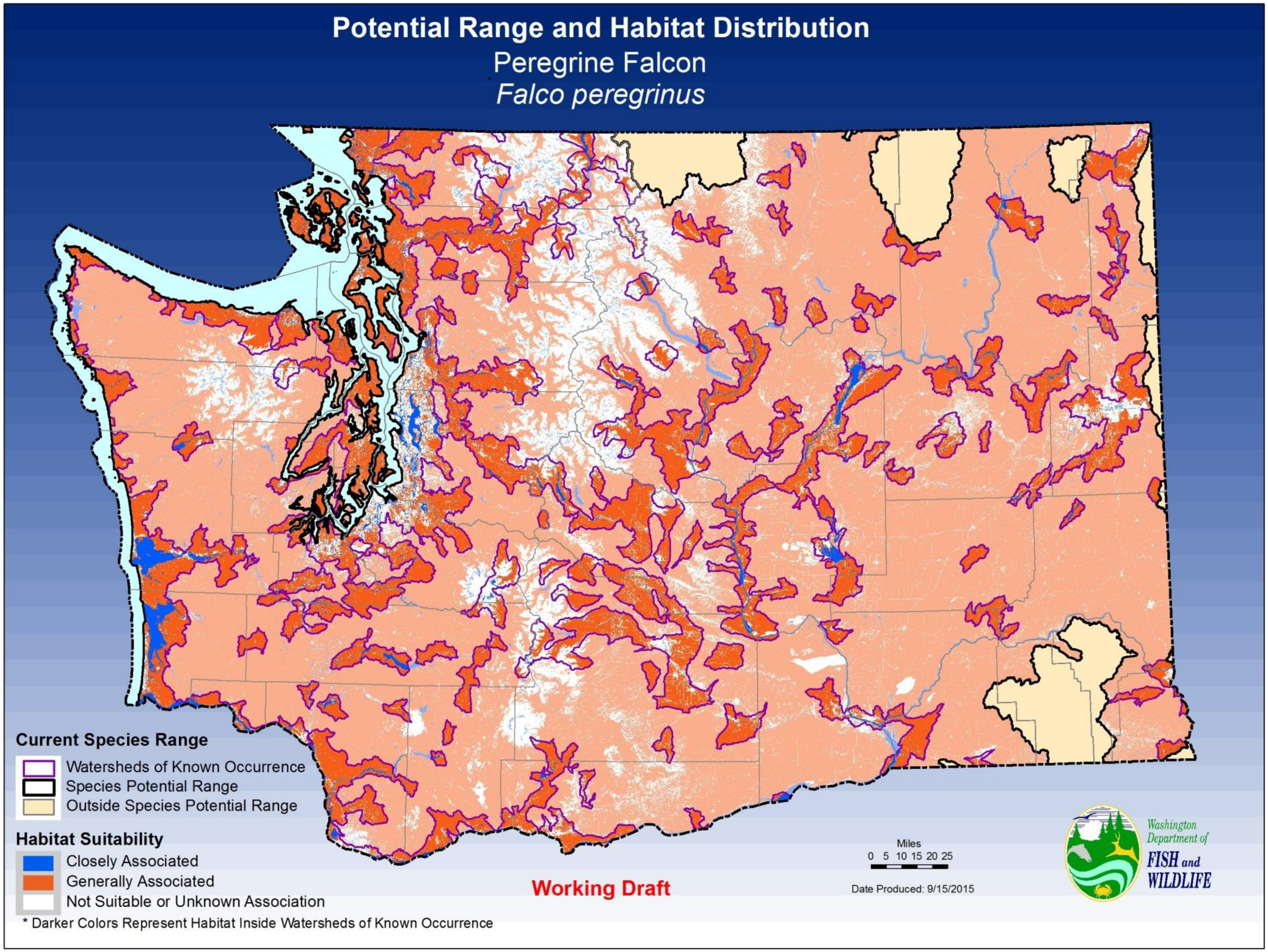
Northern Spotted Owl



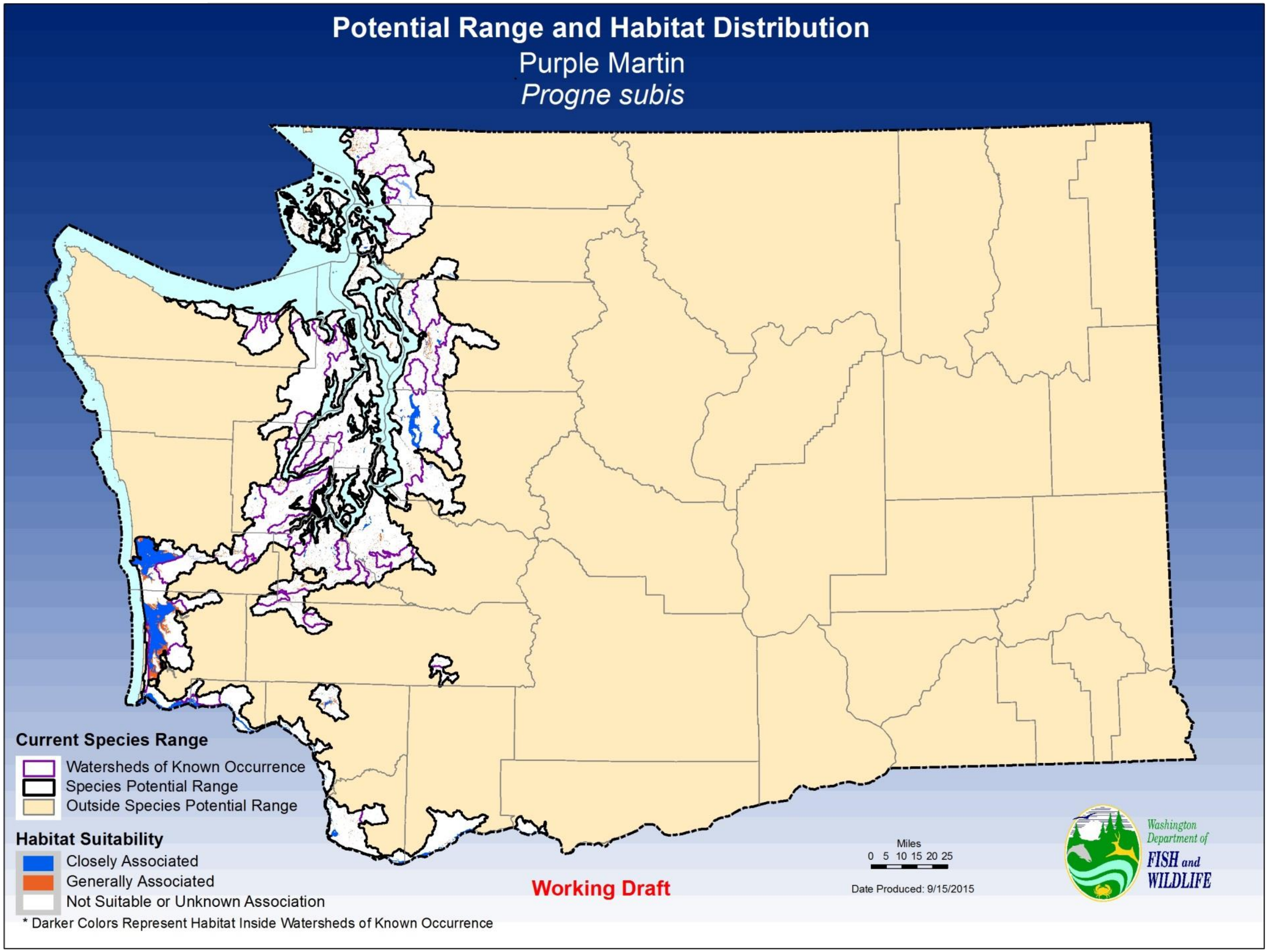
Oregon Vesper Sparrow



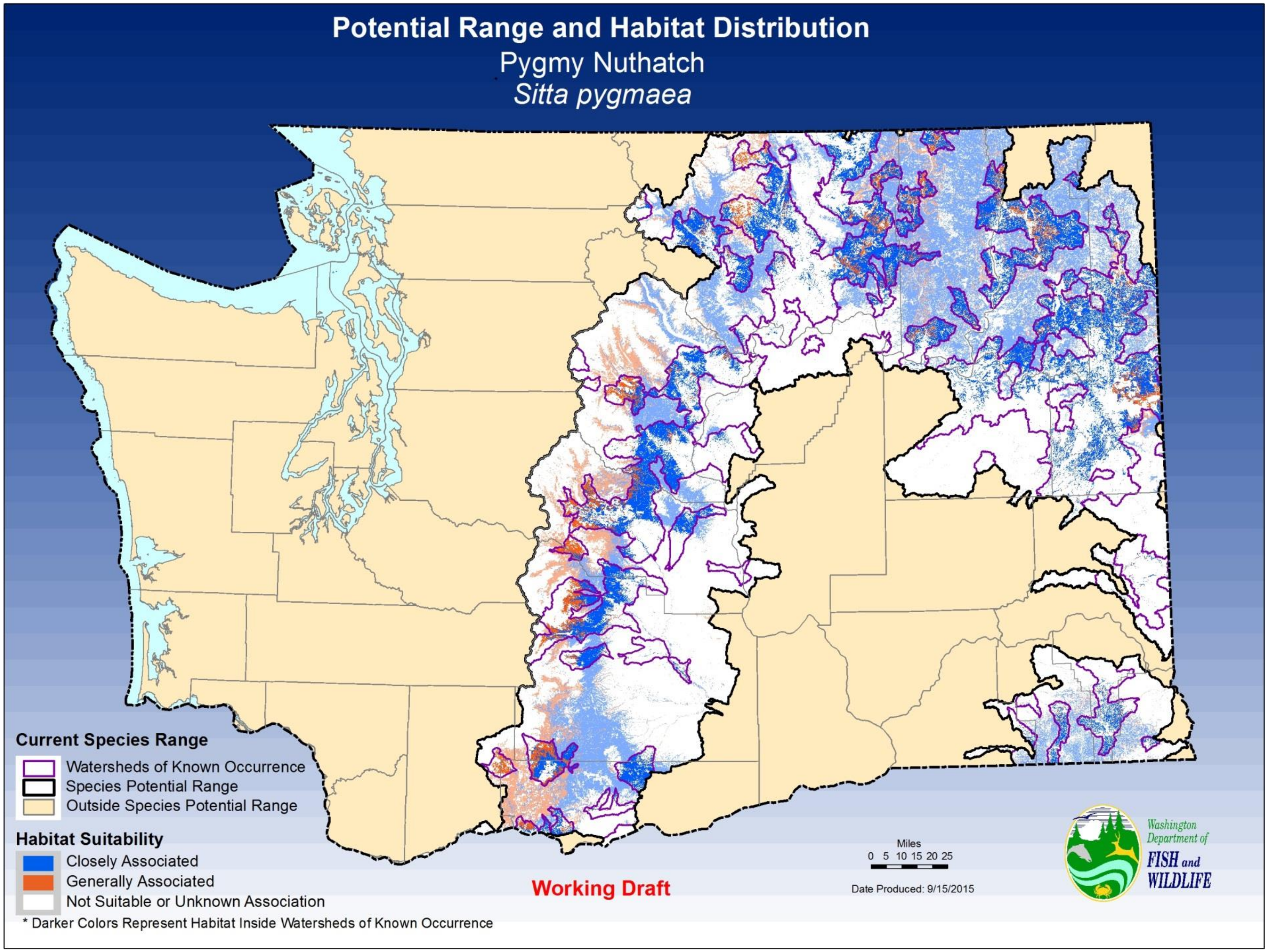
Peregrine Falcon



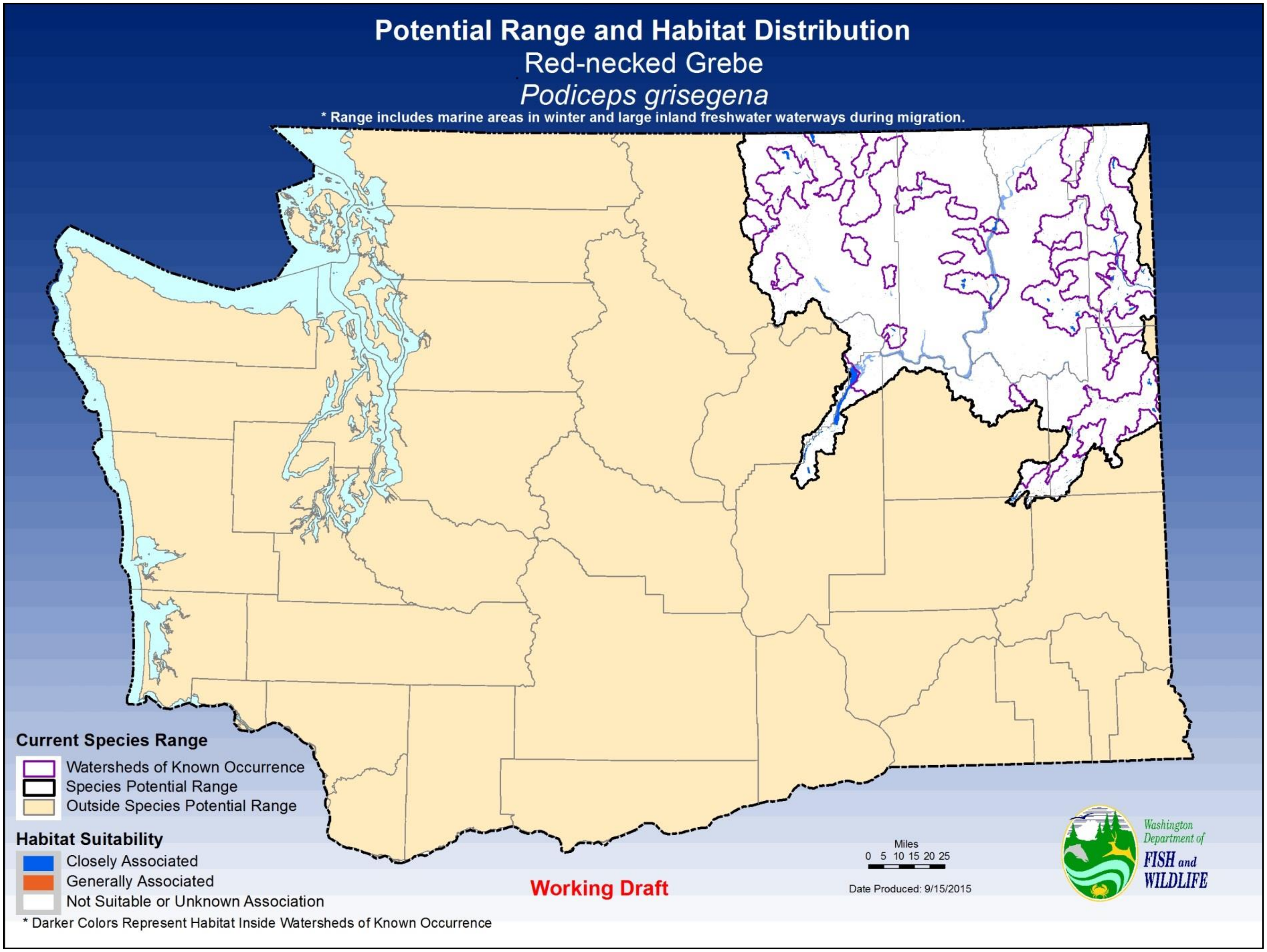
Purple Martin



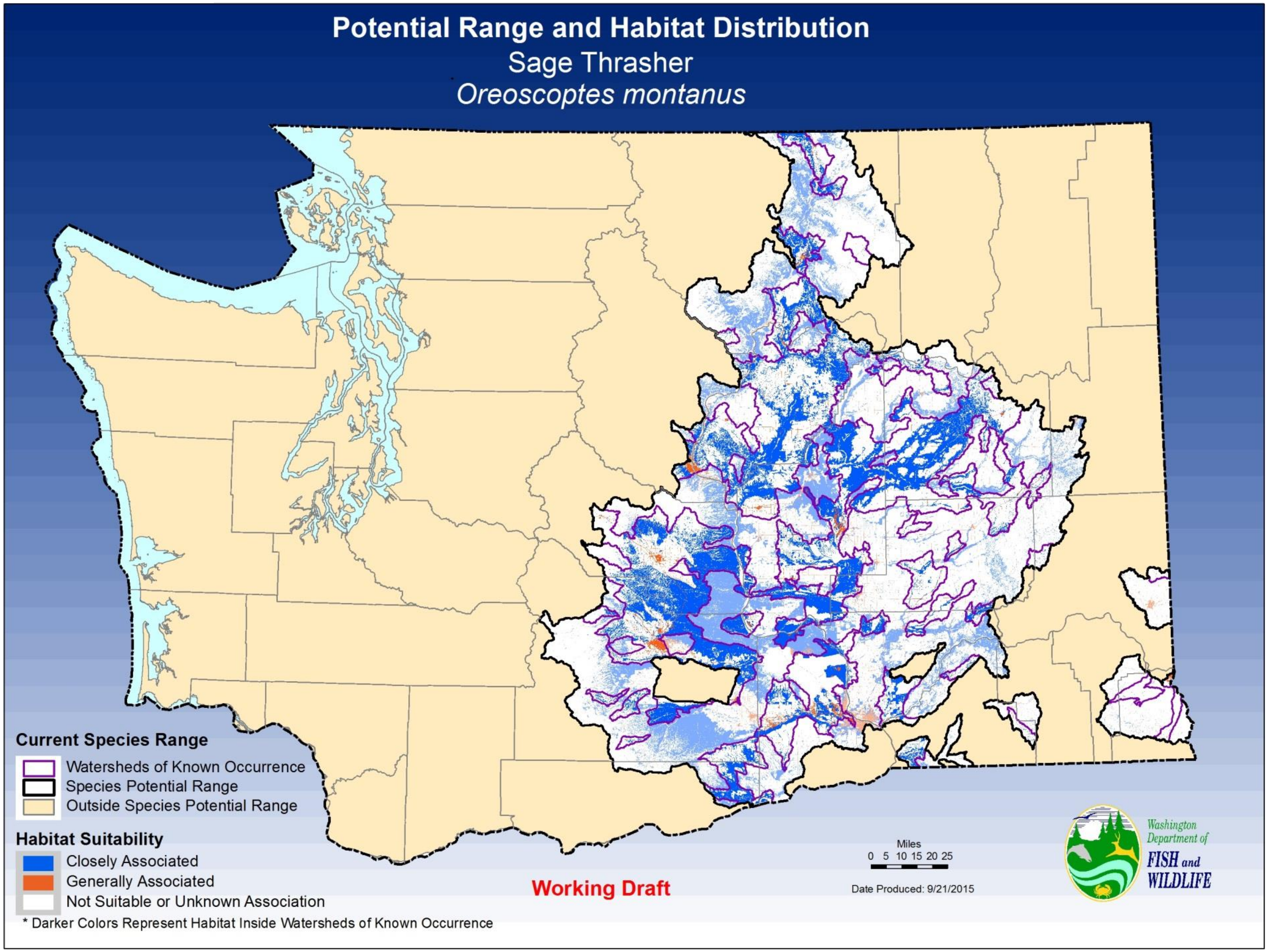
Pygmy Nuthatch



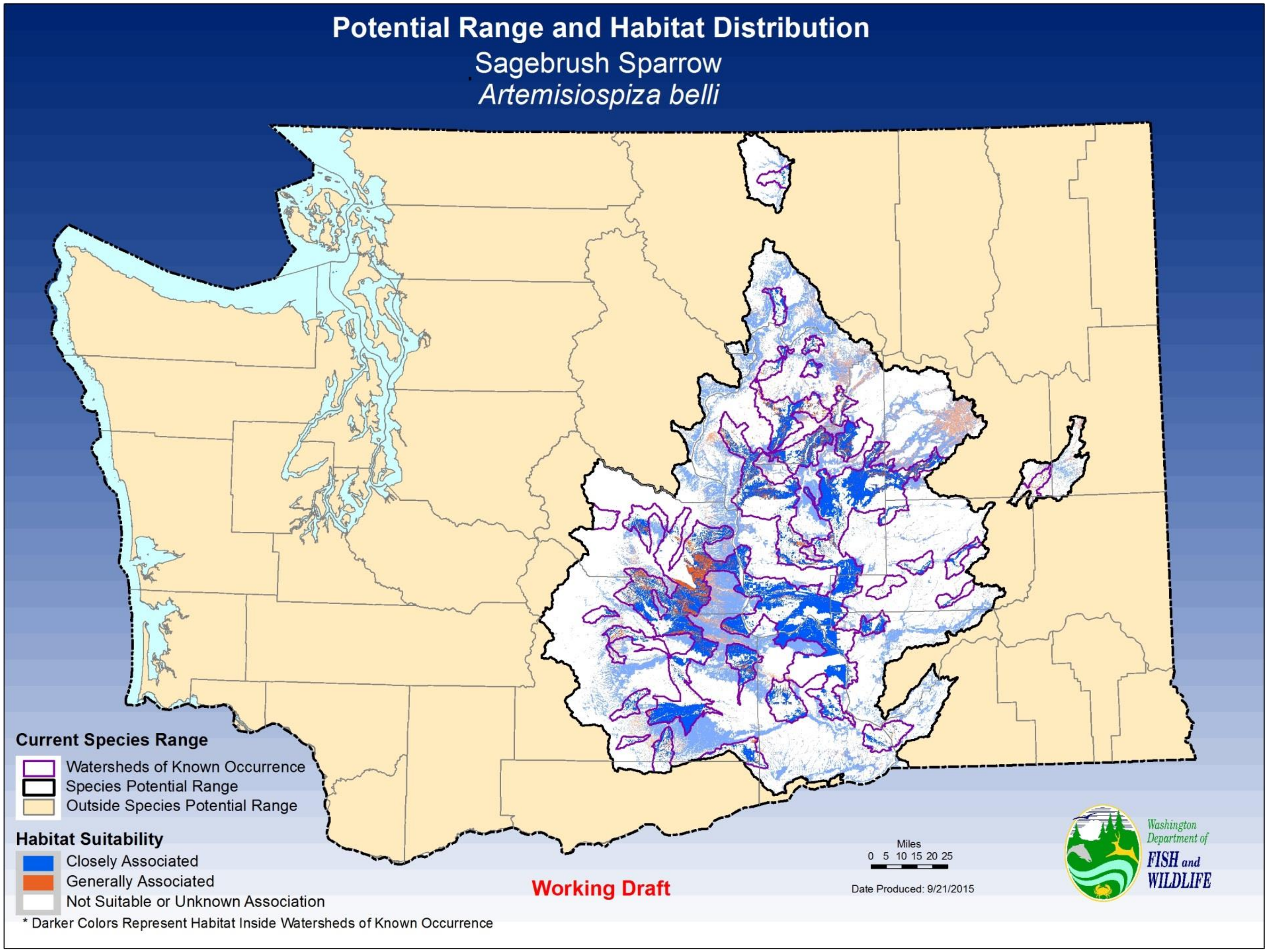
Red-necked Grebe



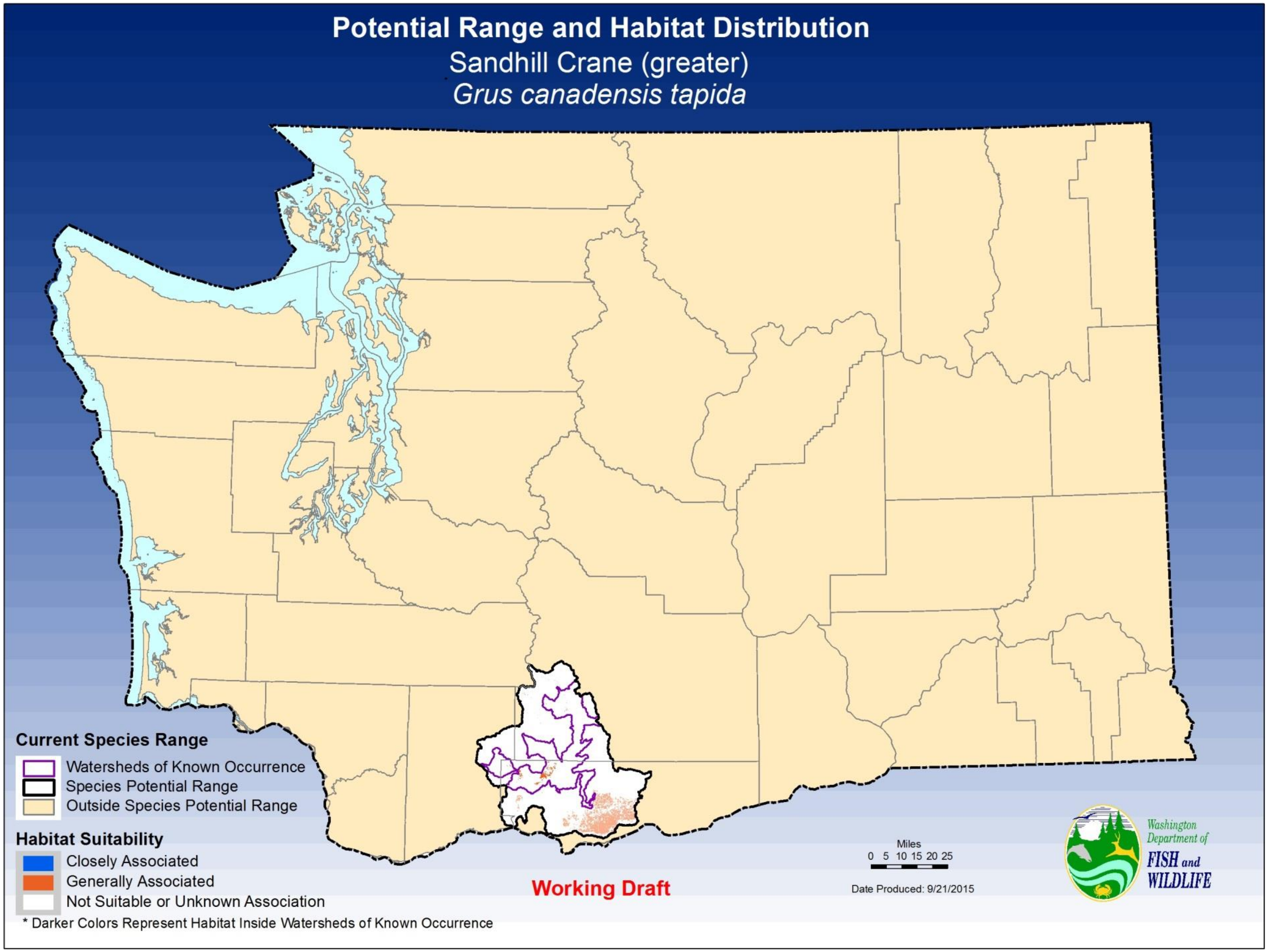
Sage Thrasher



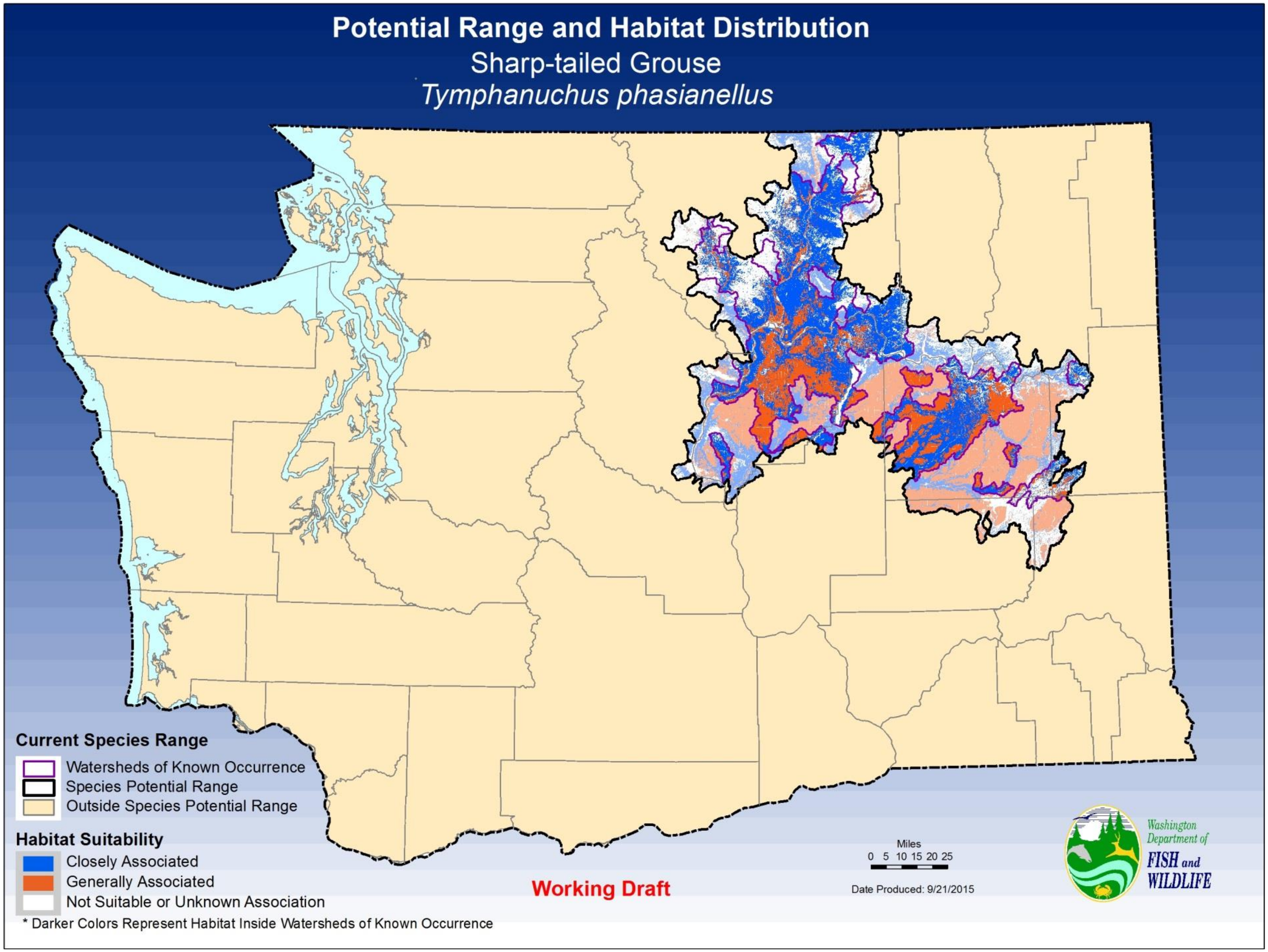
Sagebrush Sparrow



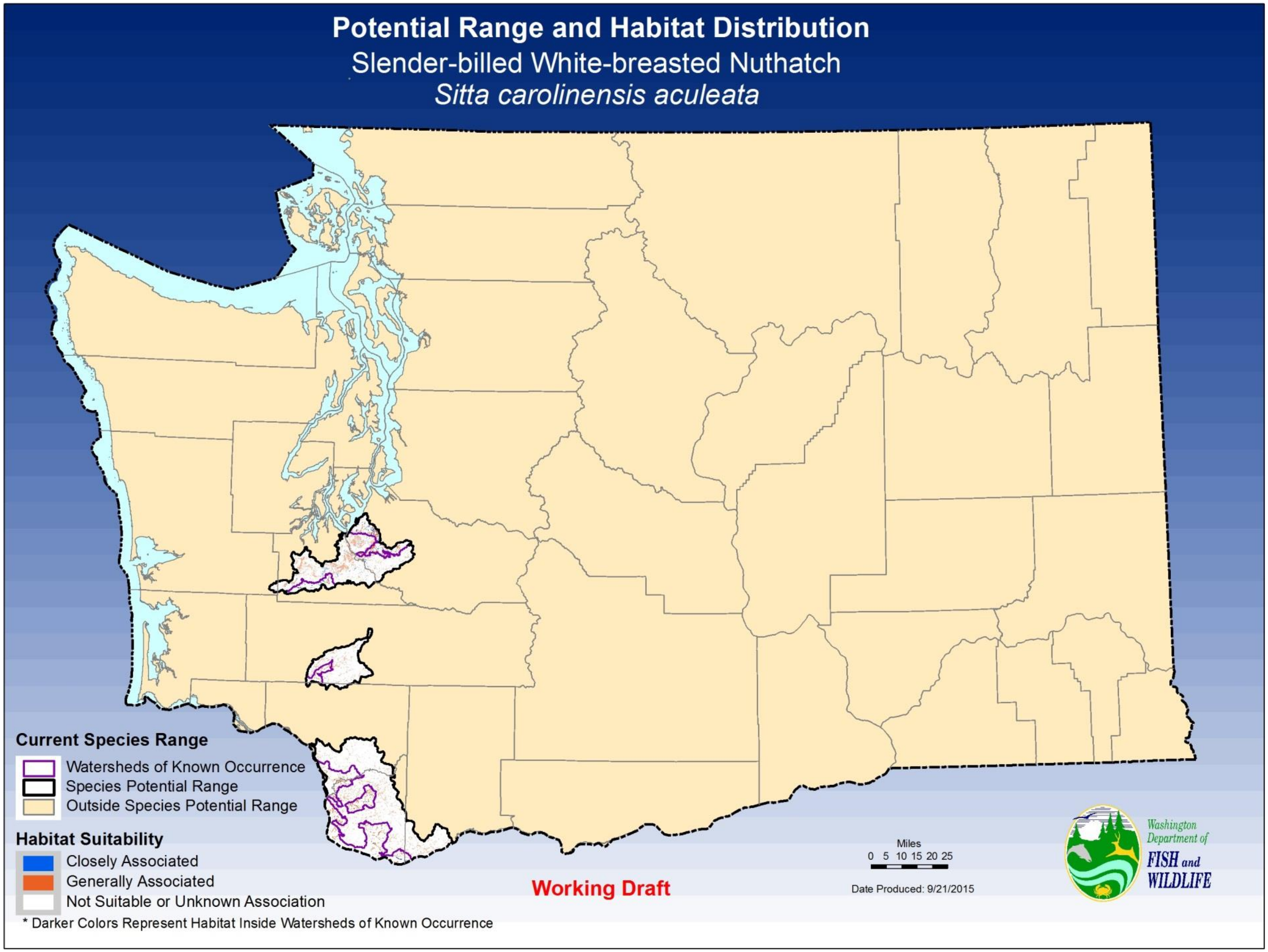
Sandhill Crane (Greater)



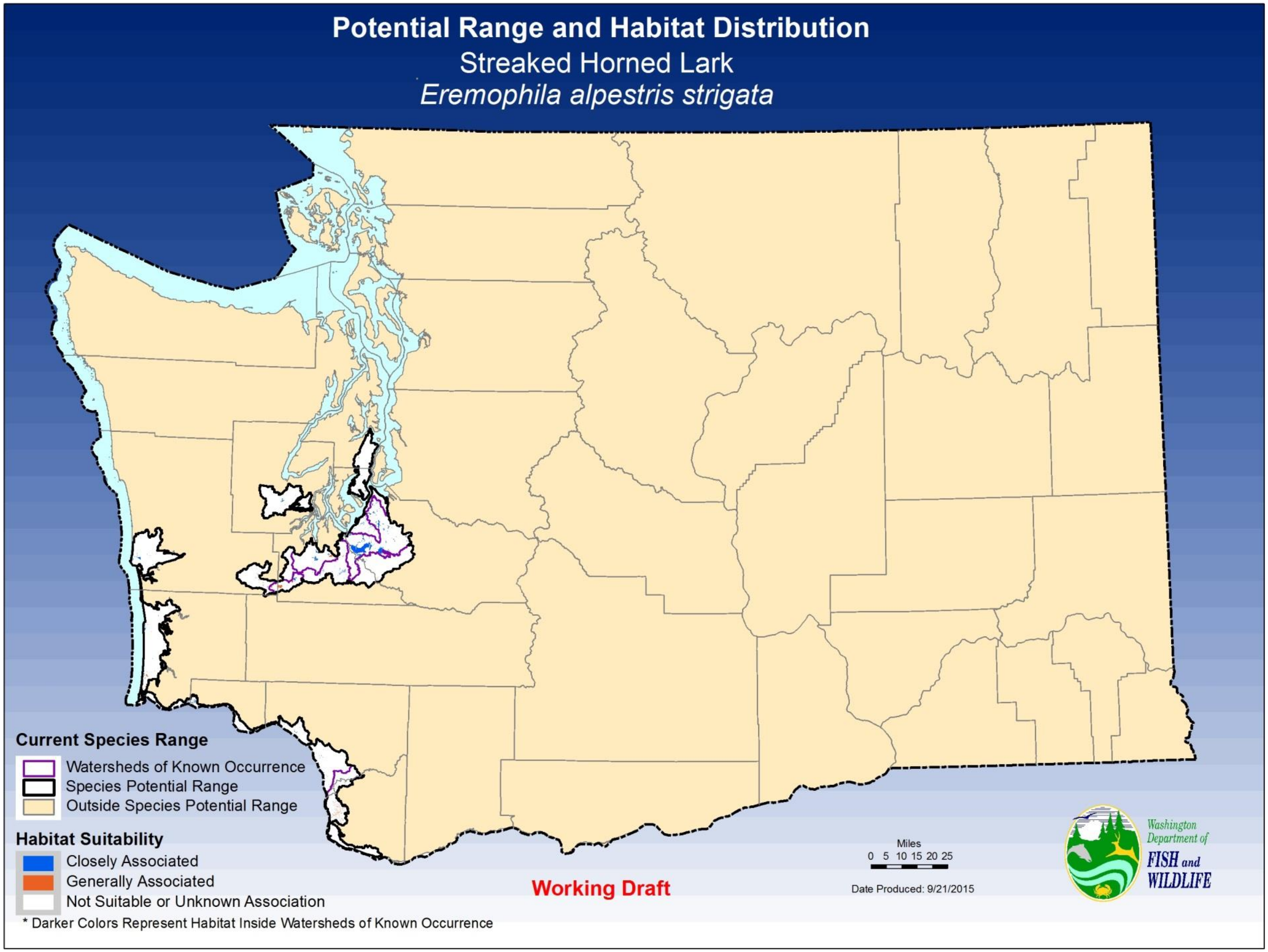
Sharp-tailed Grouse



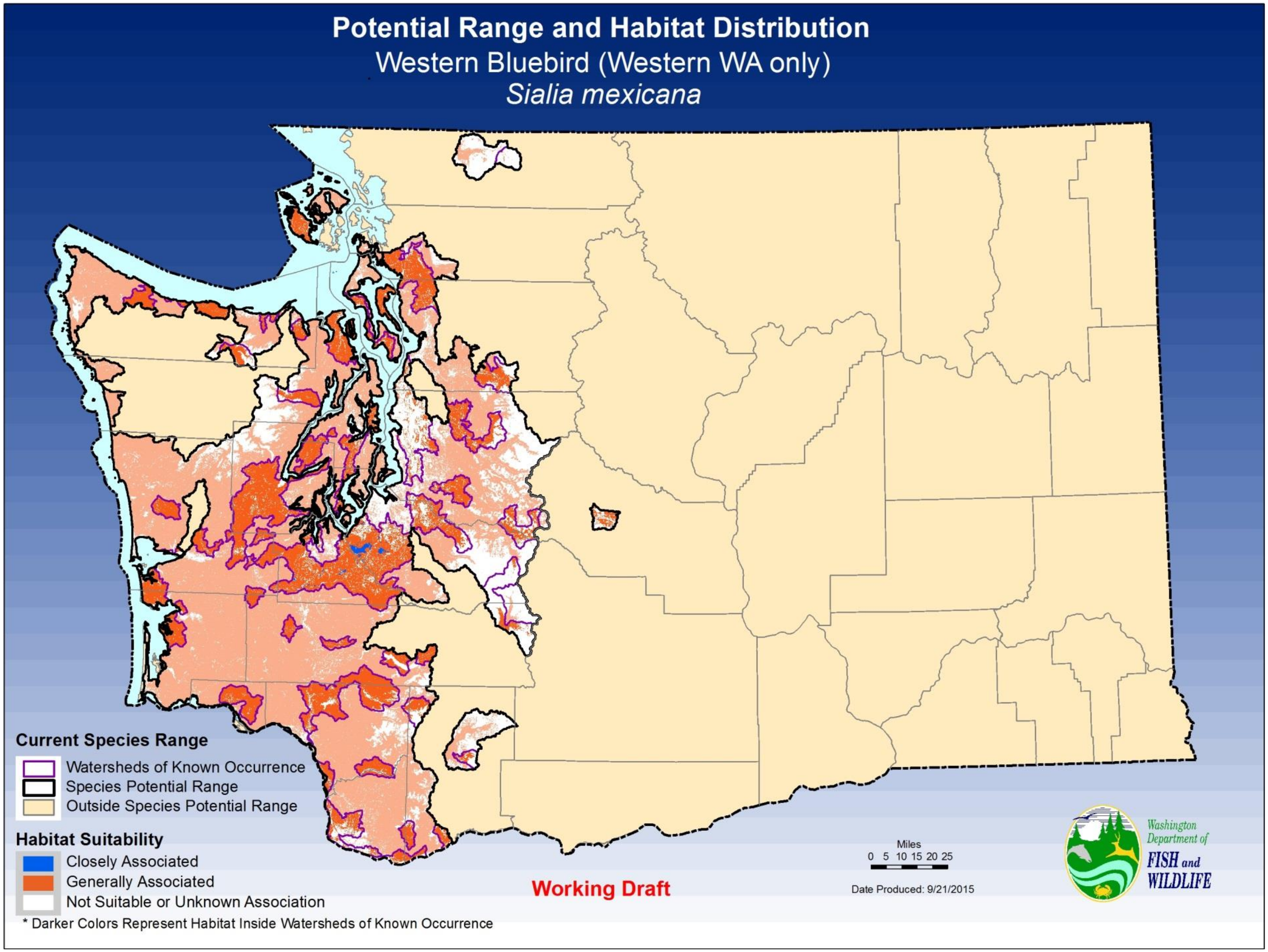
Slender-billed White-breasted Nuthatch



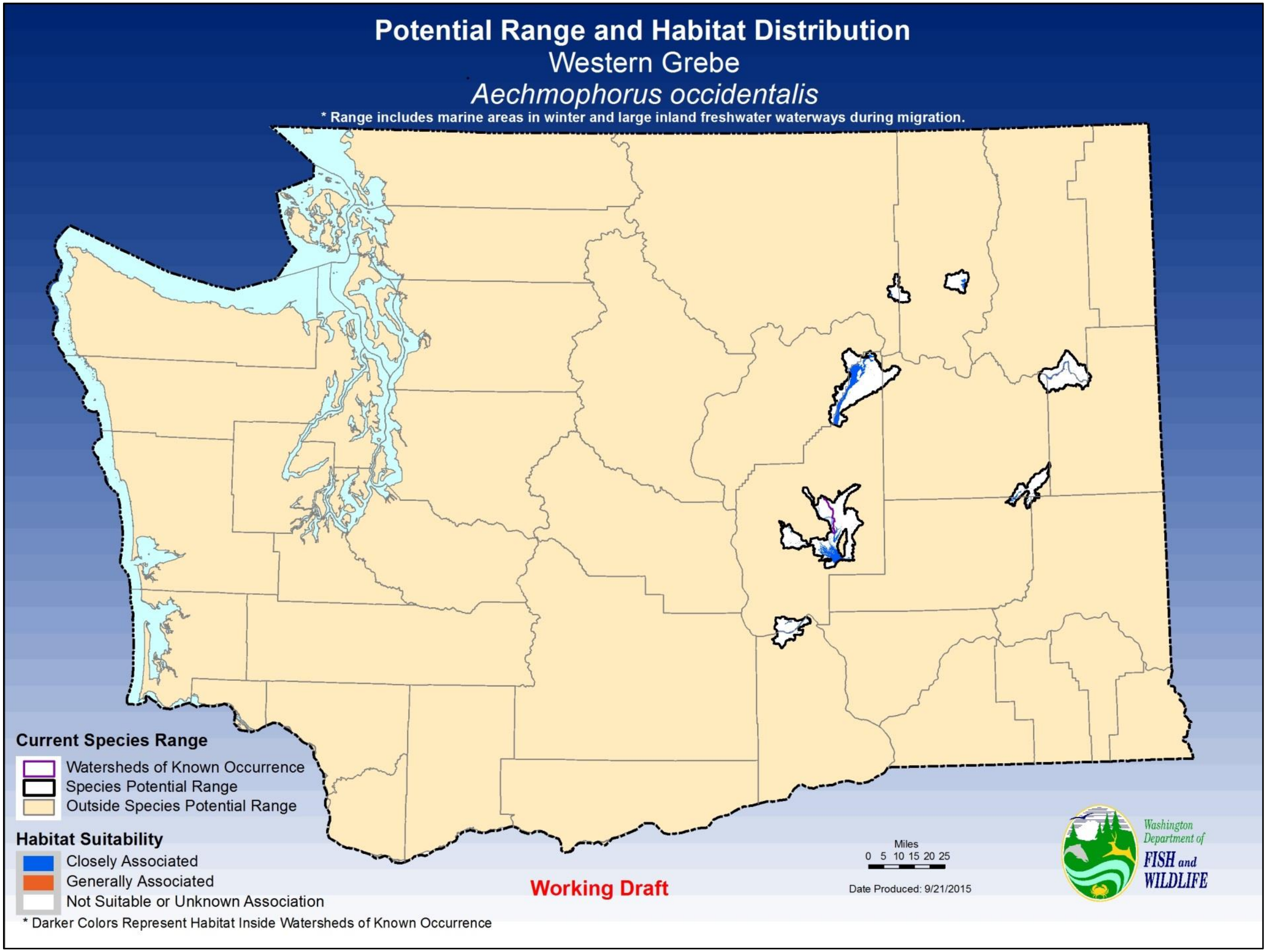
Streaked Horned Lark



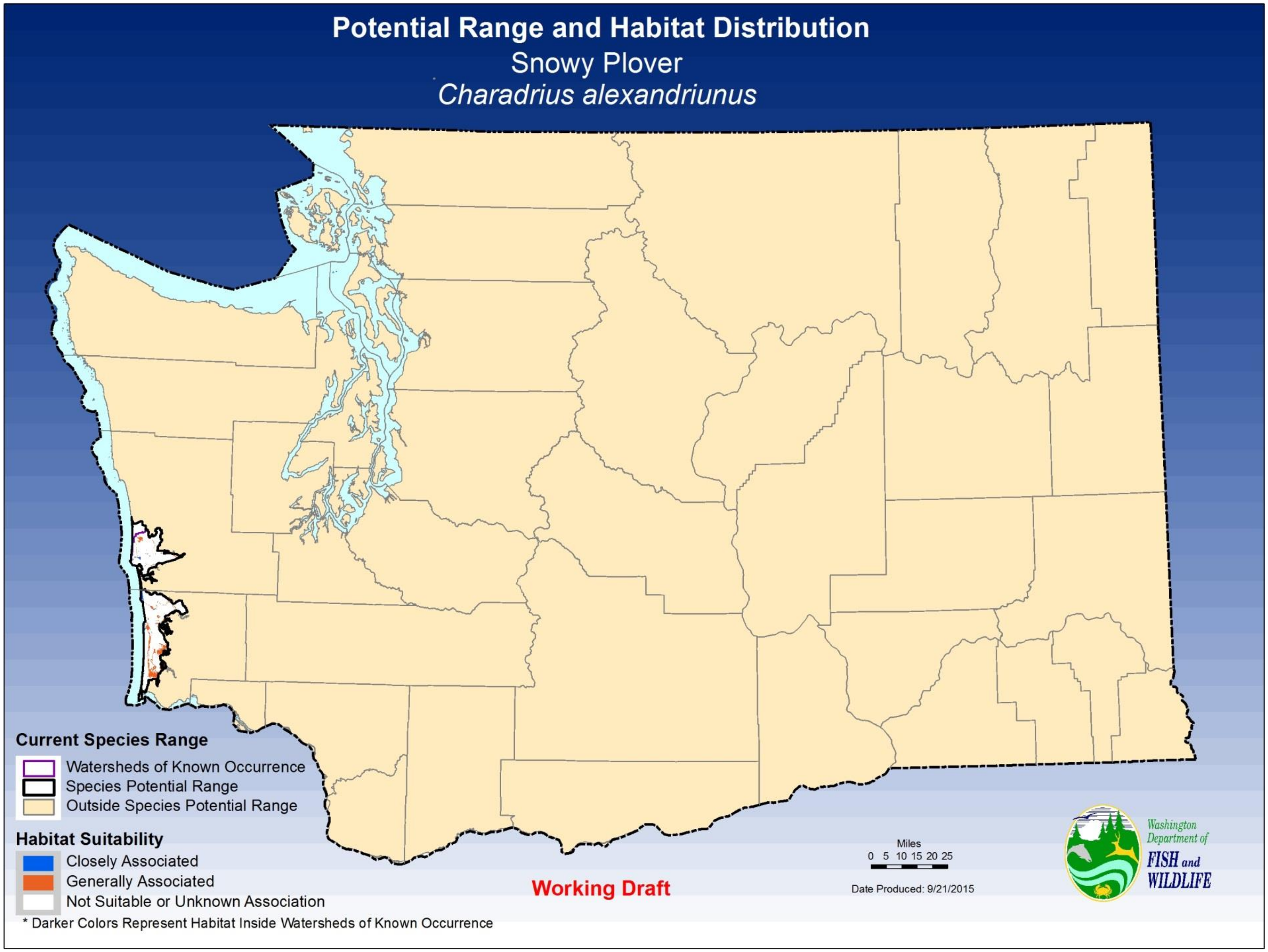
Western Bluebird (Western WA only)



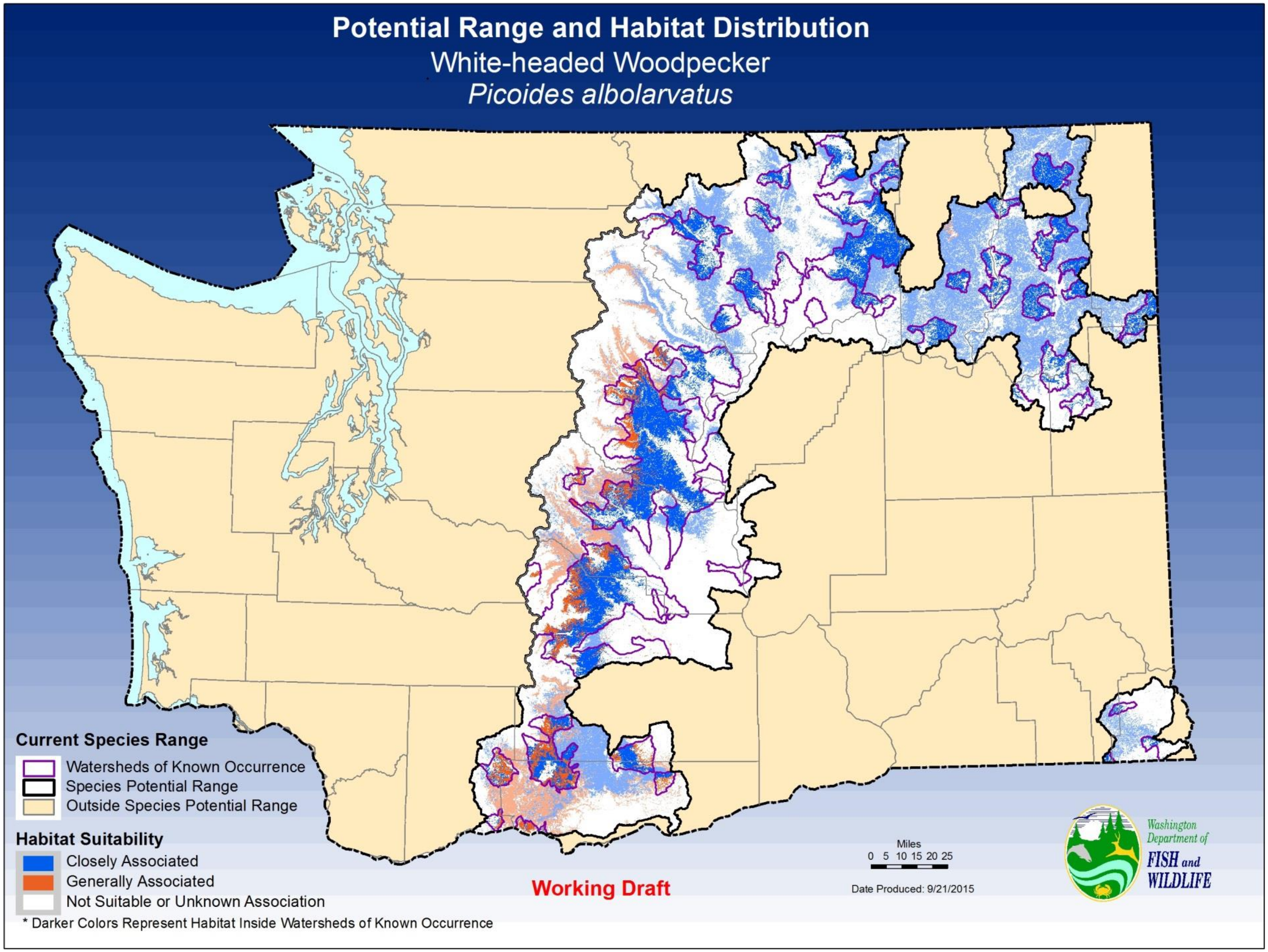
Western Grebe



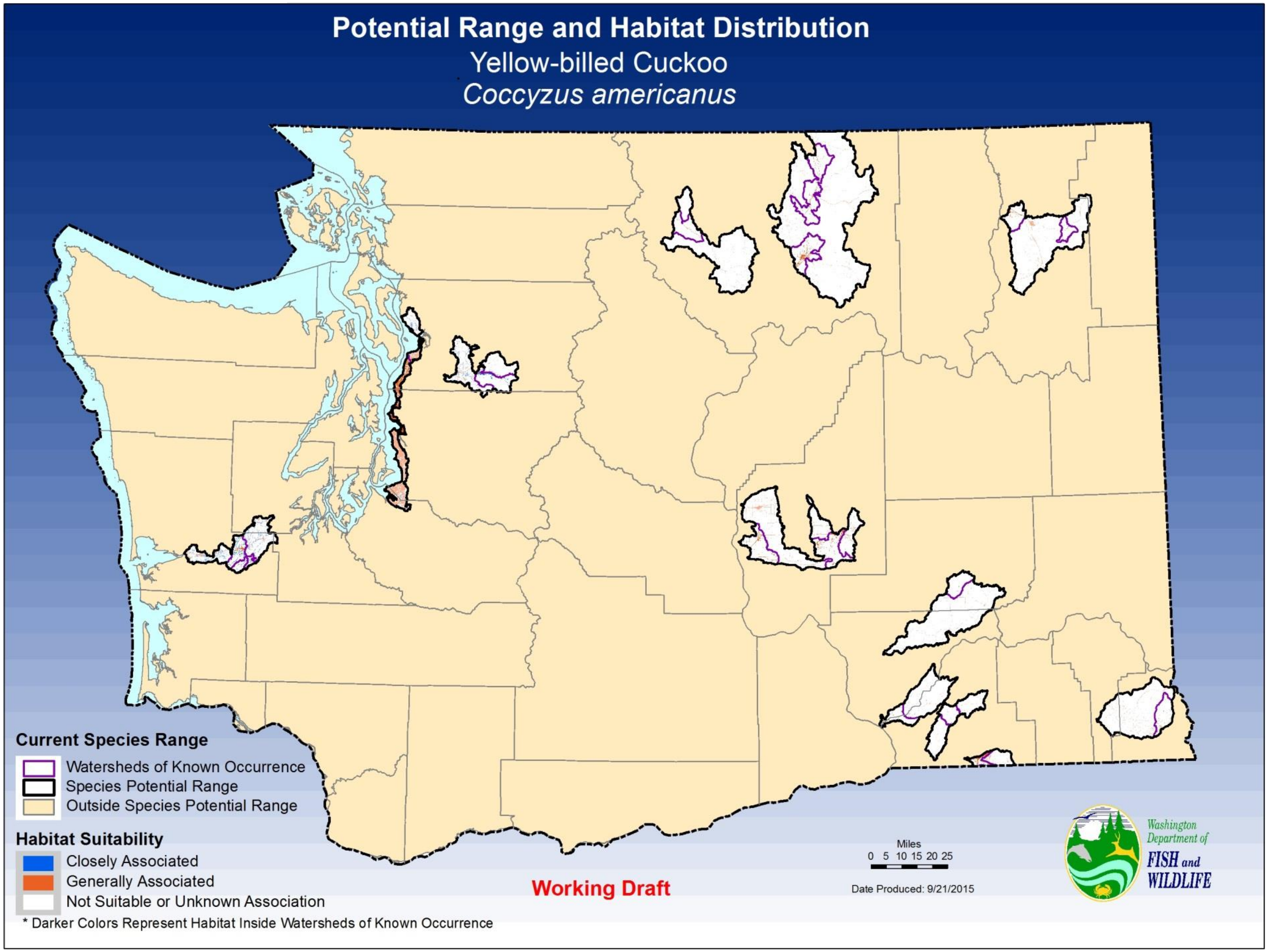
Western Snowy Plover



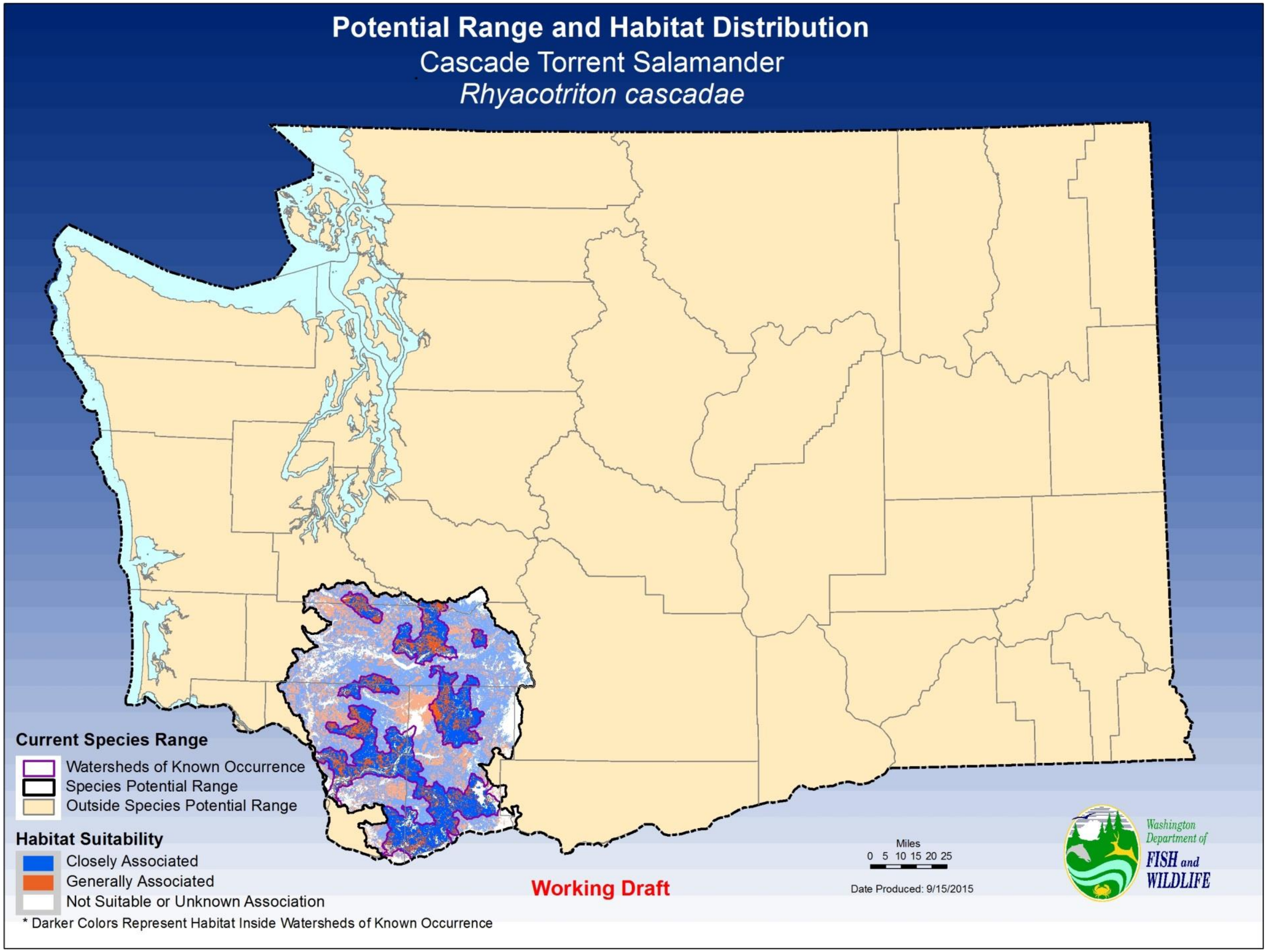
White-headed Woodpecker



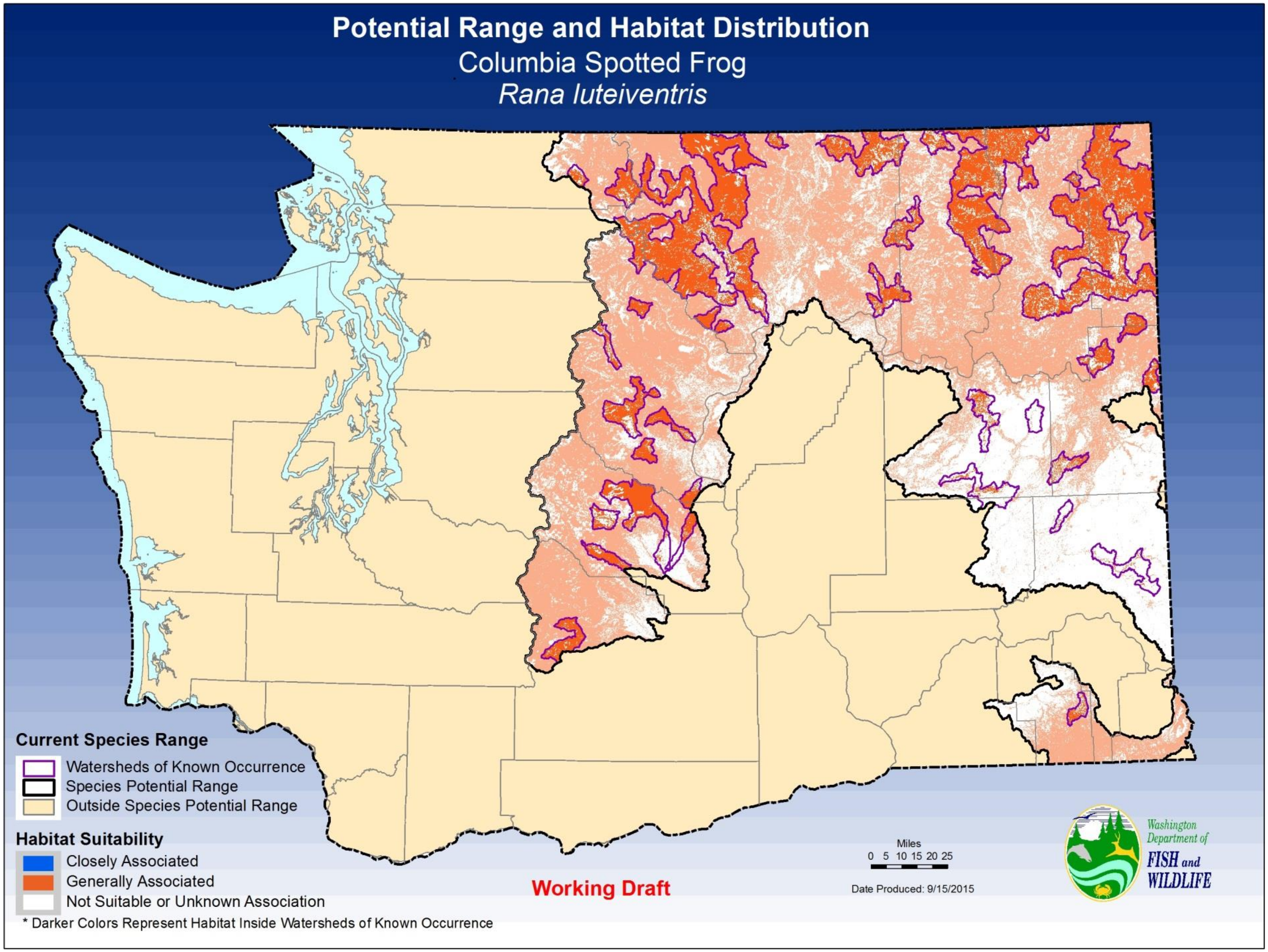
Yellow-billed Cuckoo



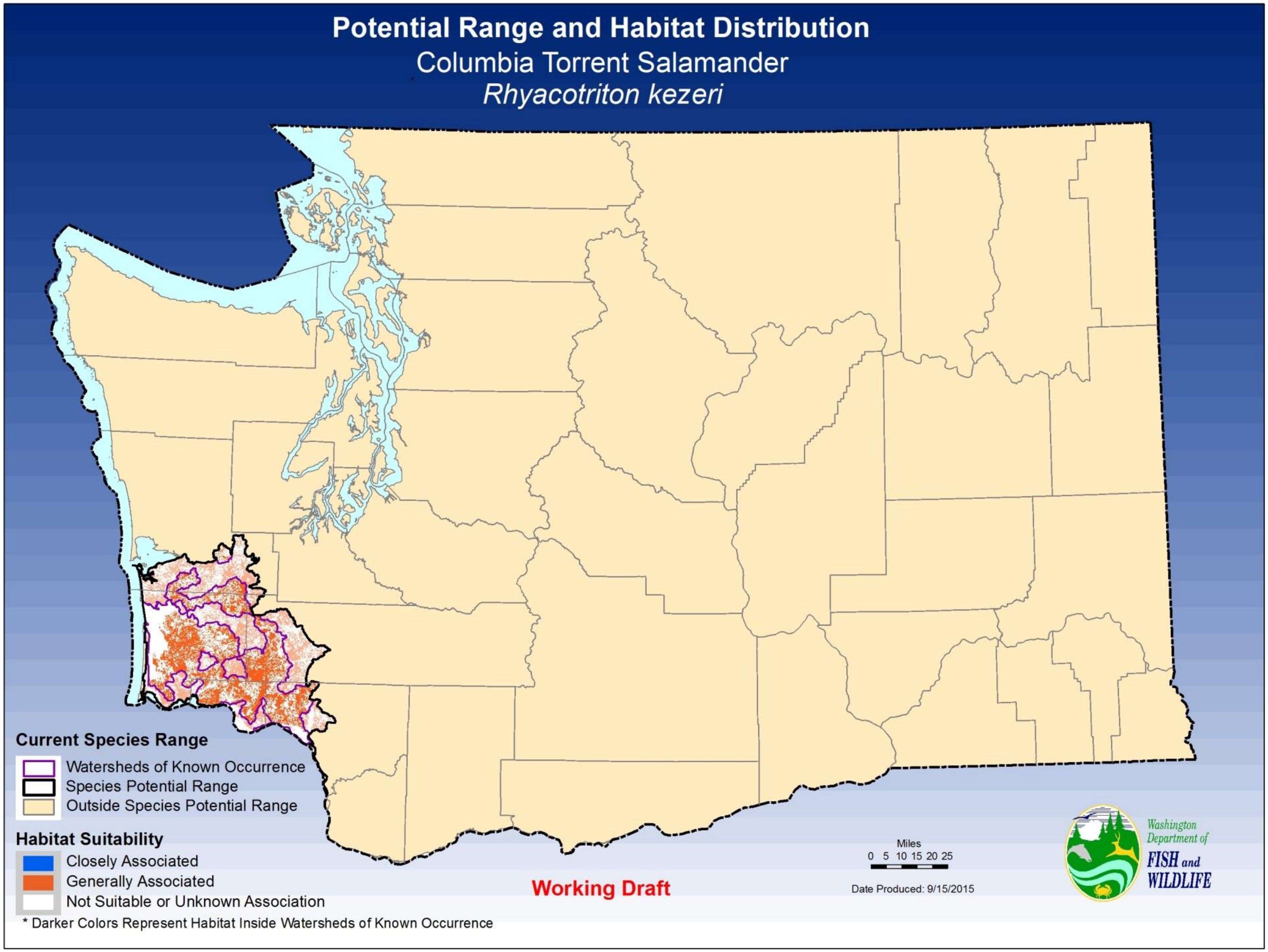
Cascade Torrent Salamander



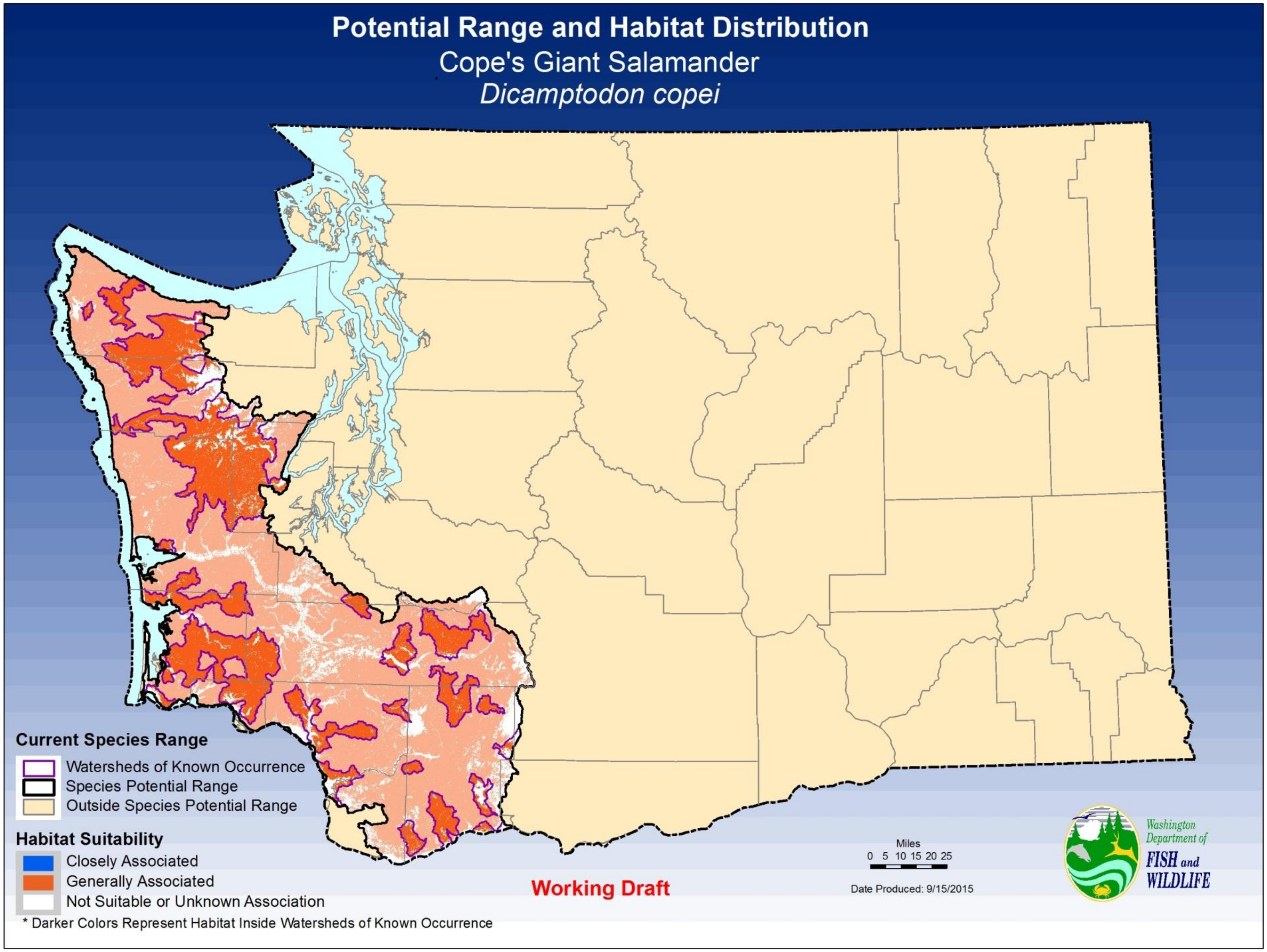
Columbia Spotted Frog



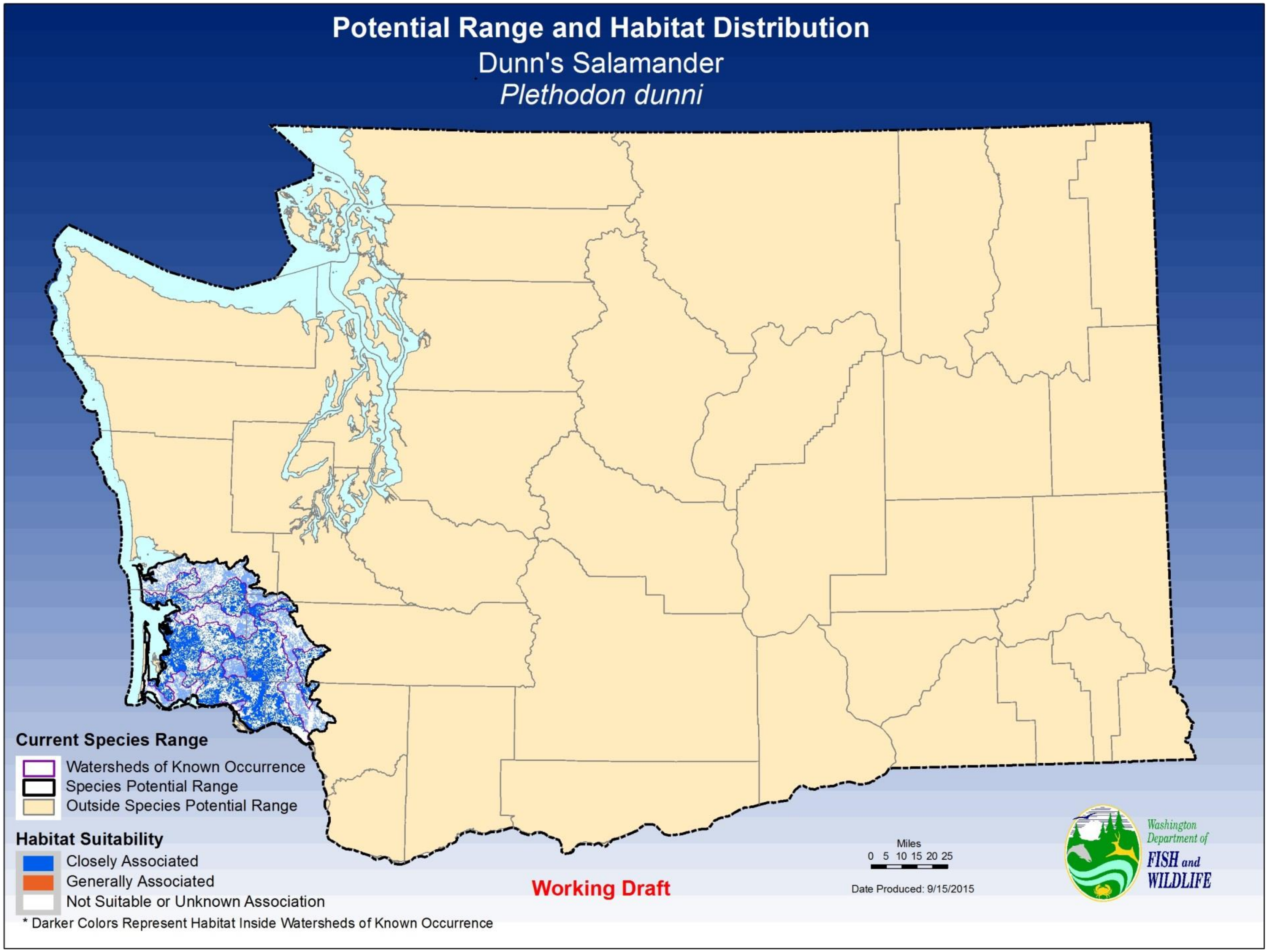
Columbia Torrent Salamander



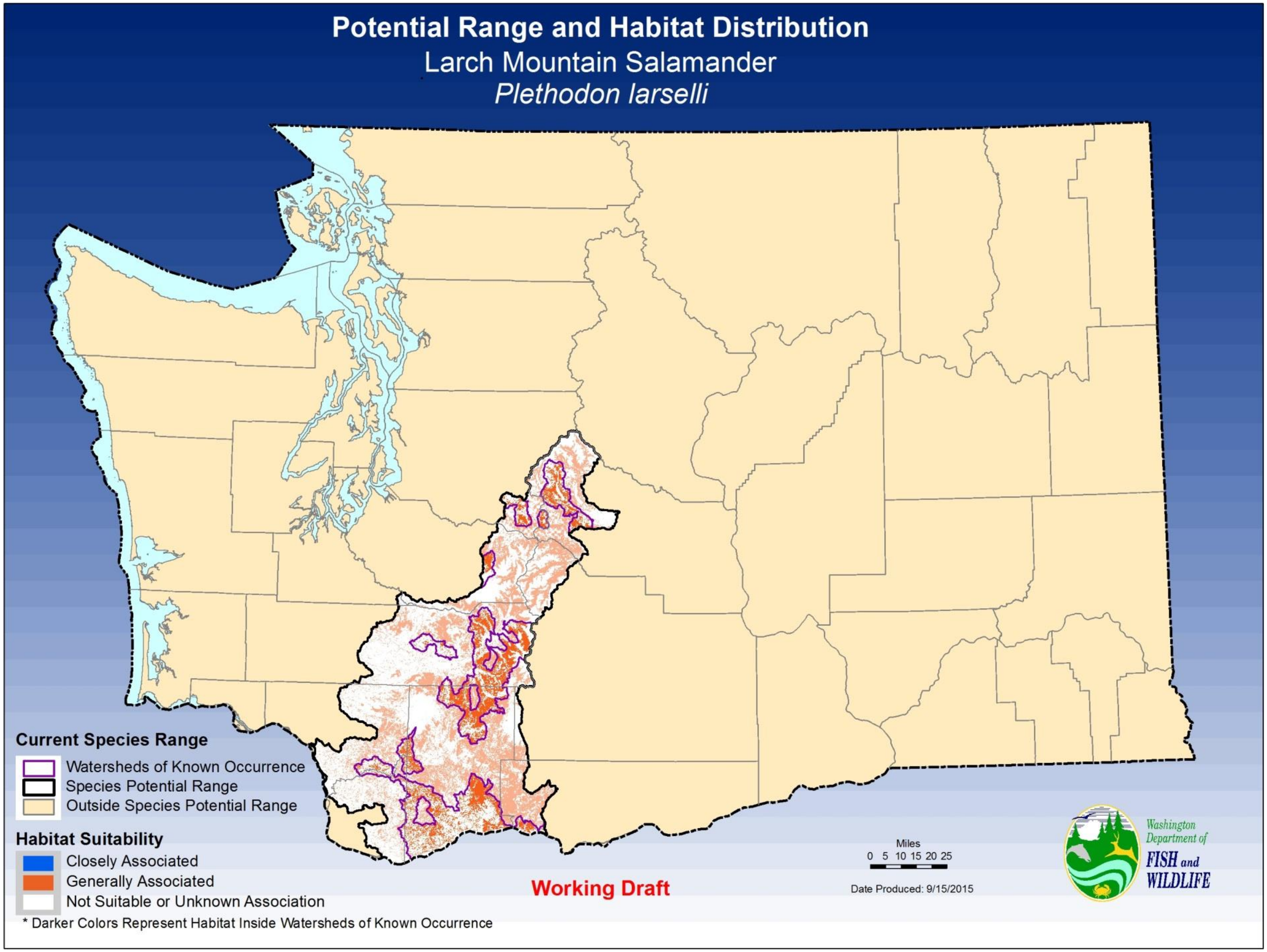
Cope's Giant Salamander



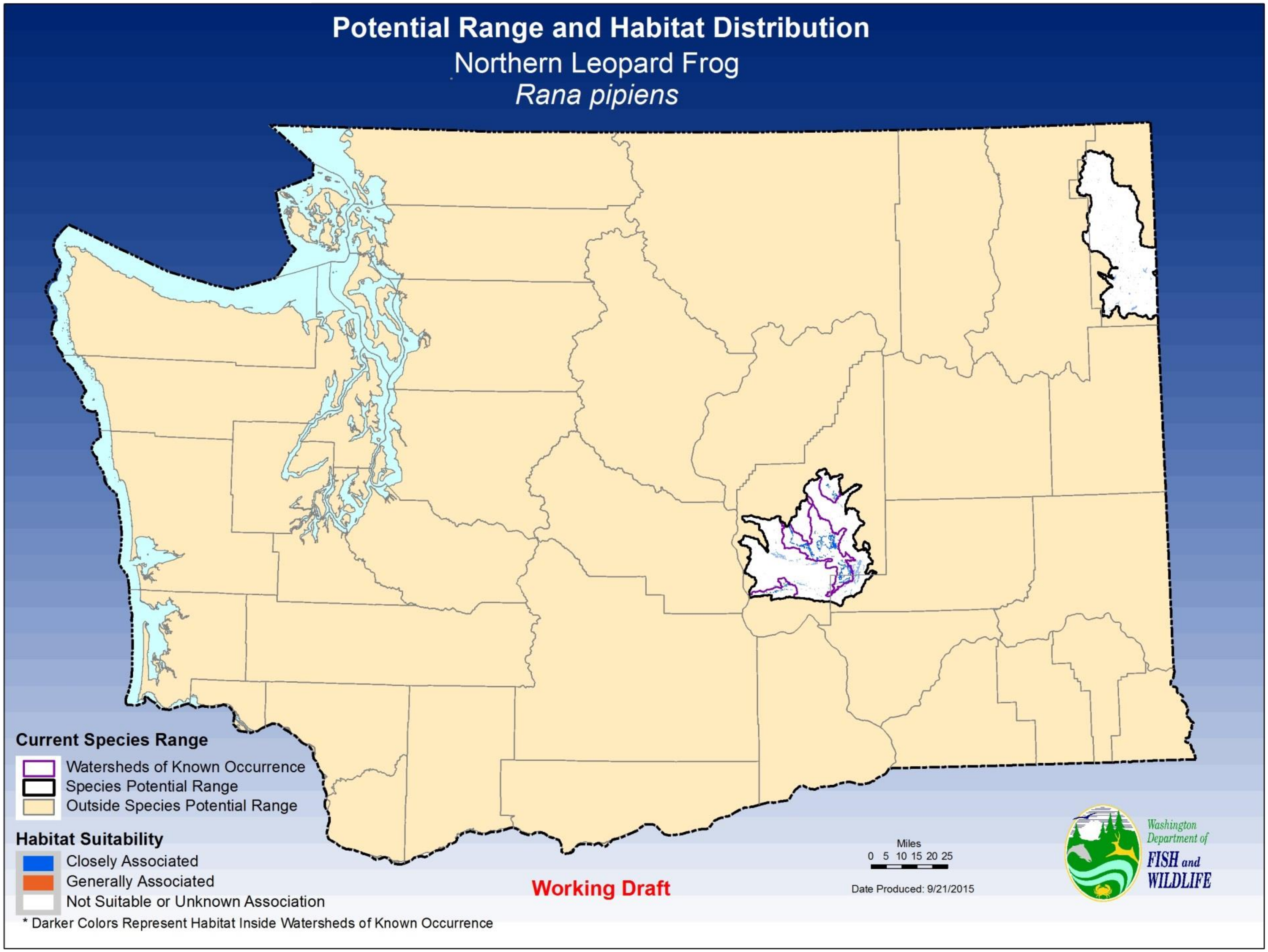
Dunn's Salamander



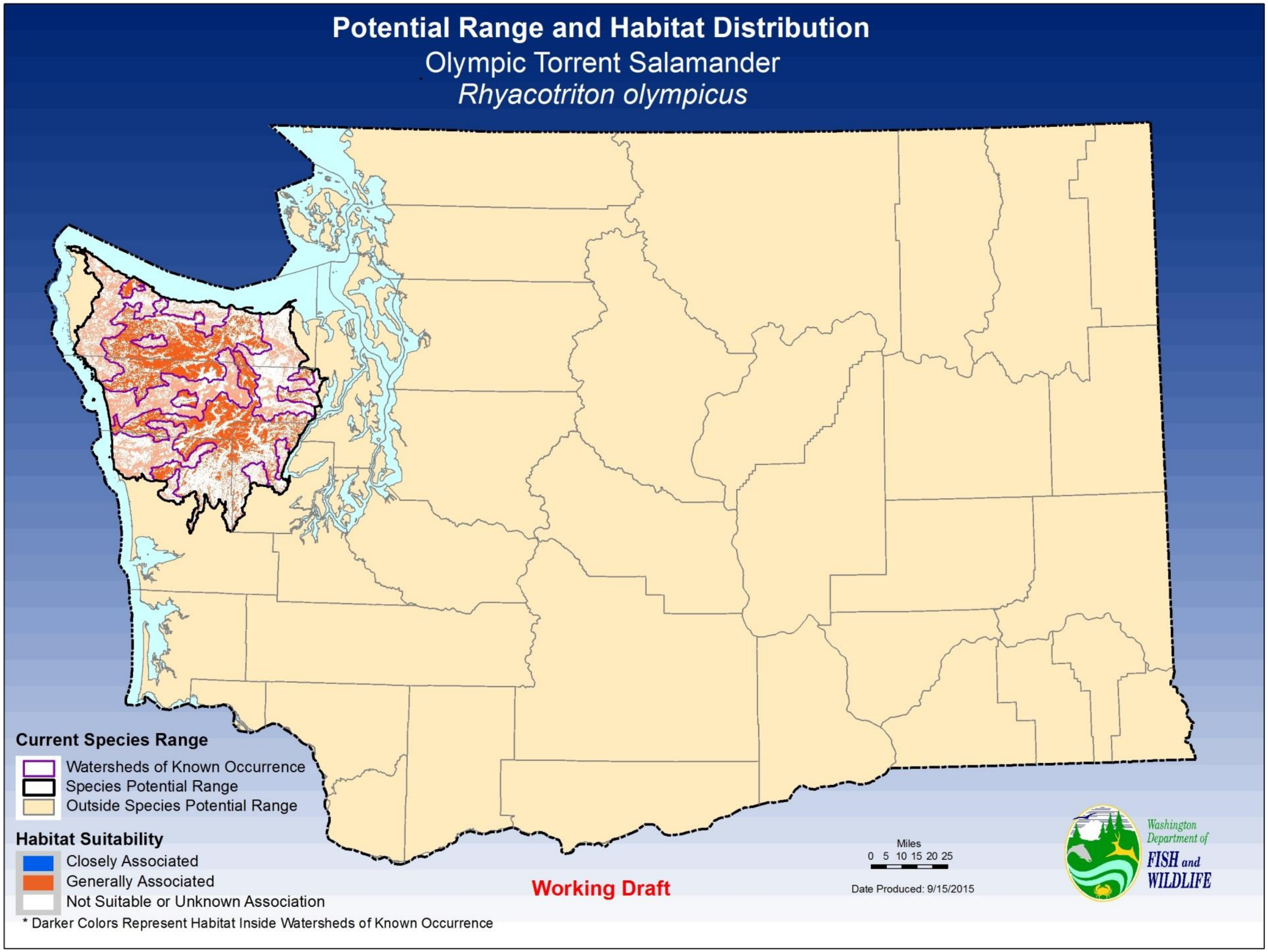
Larch Mountain Salamander



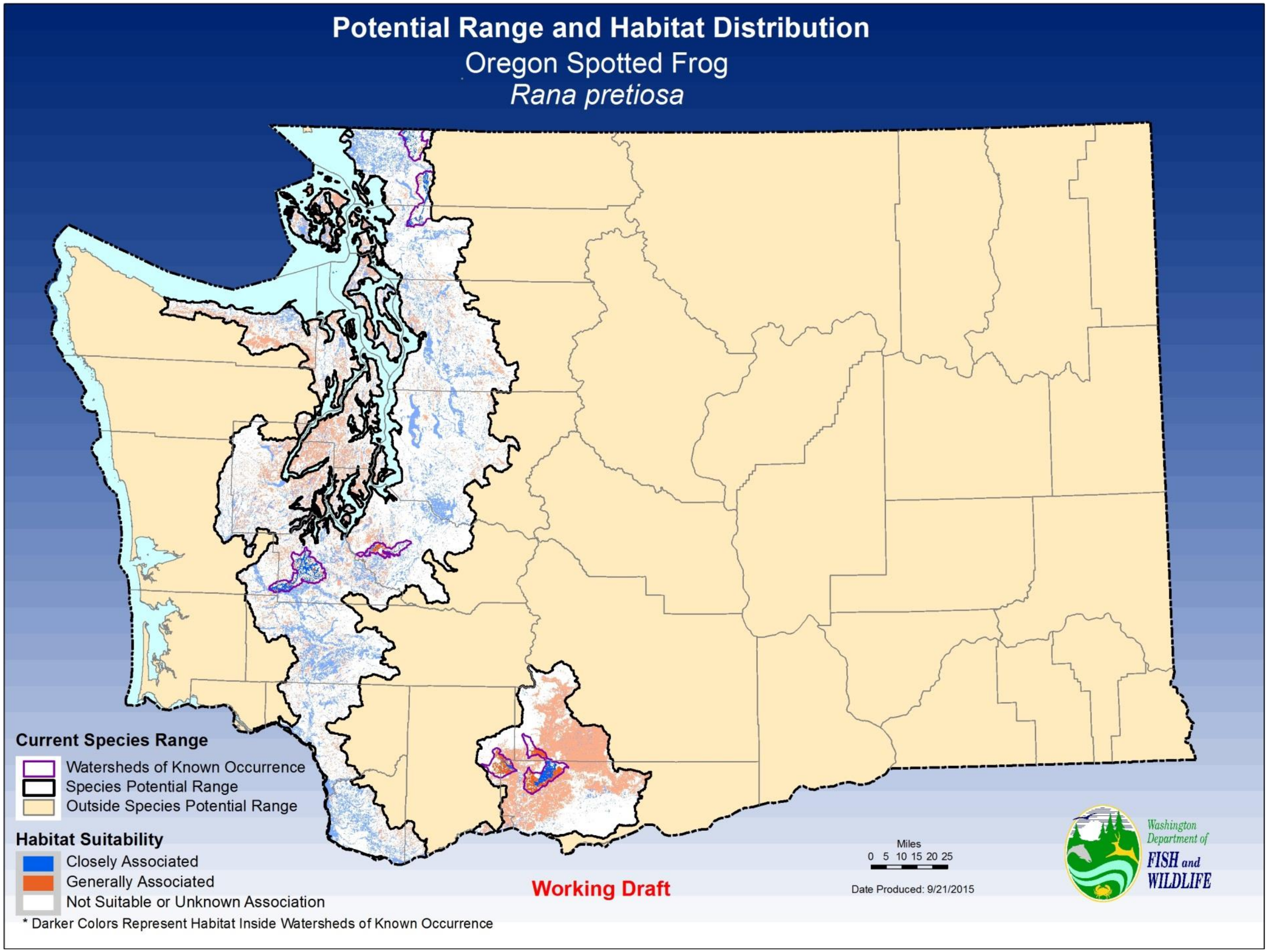
Northern Leopard Frog



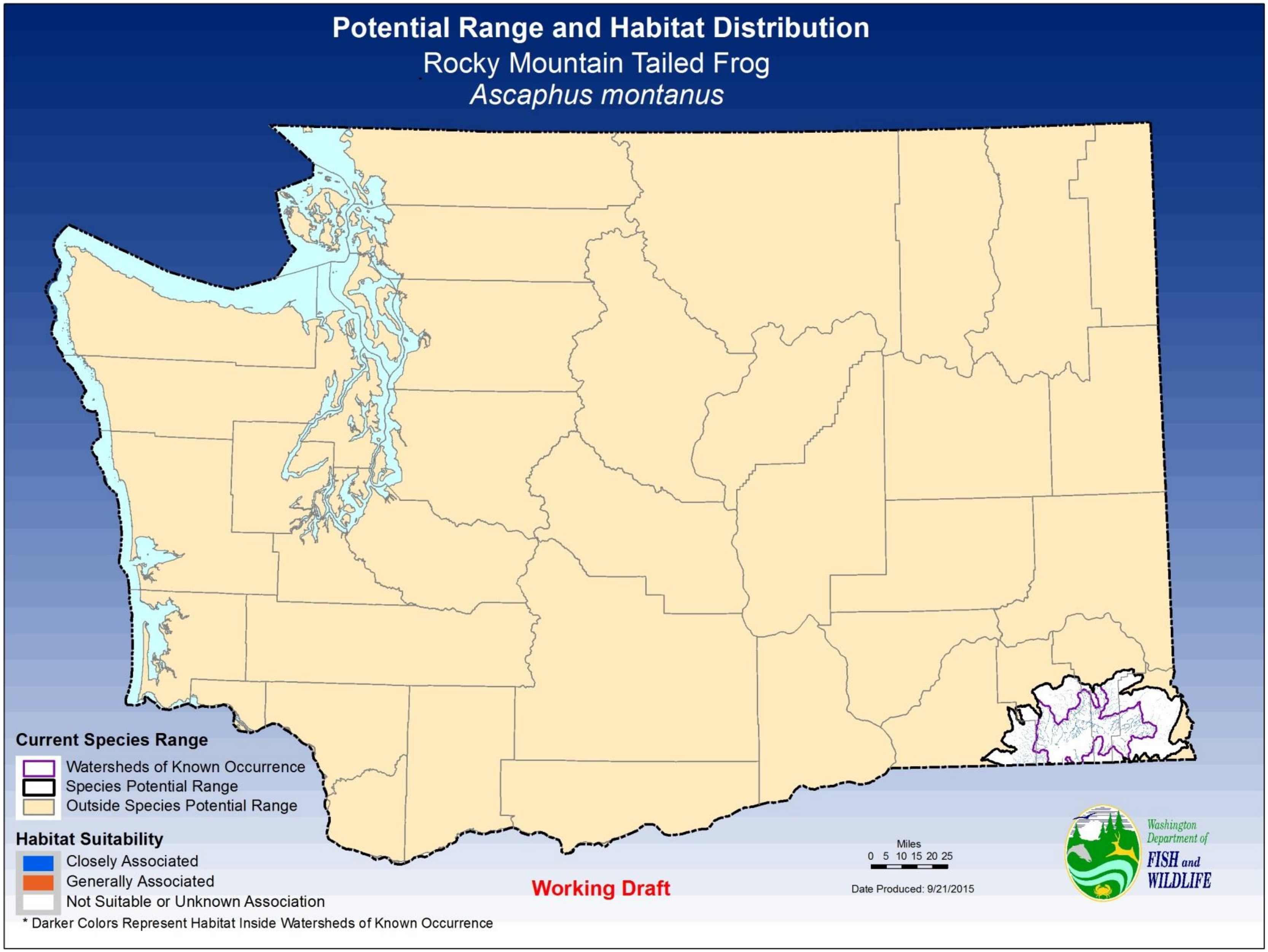
Olympic Torrent Salamander



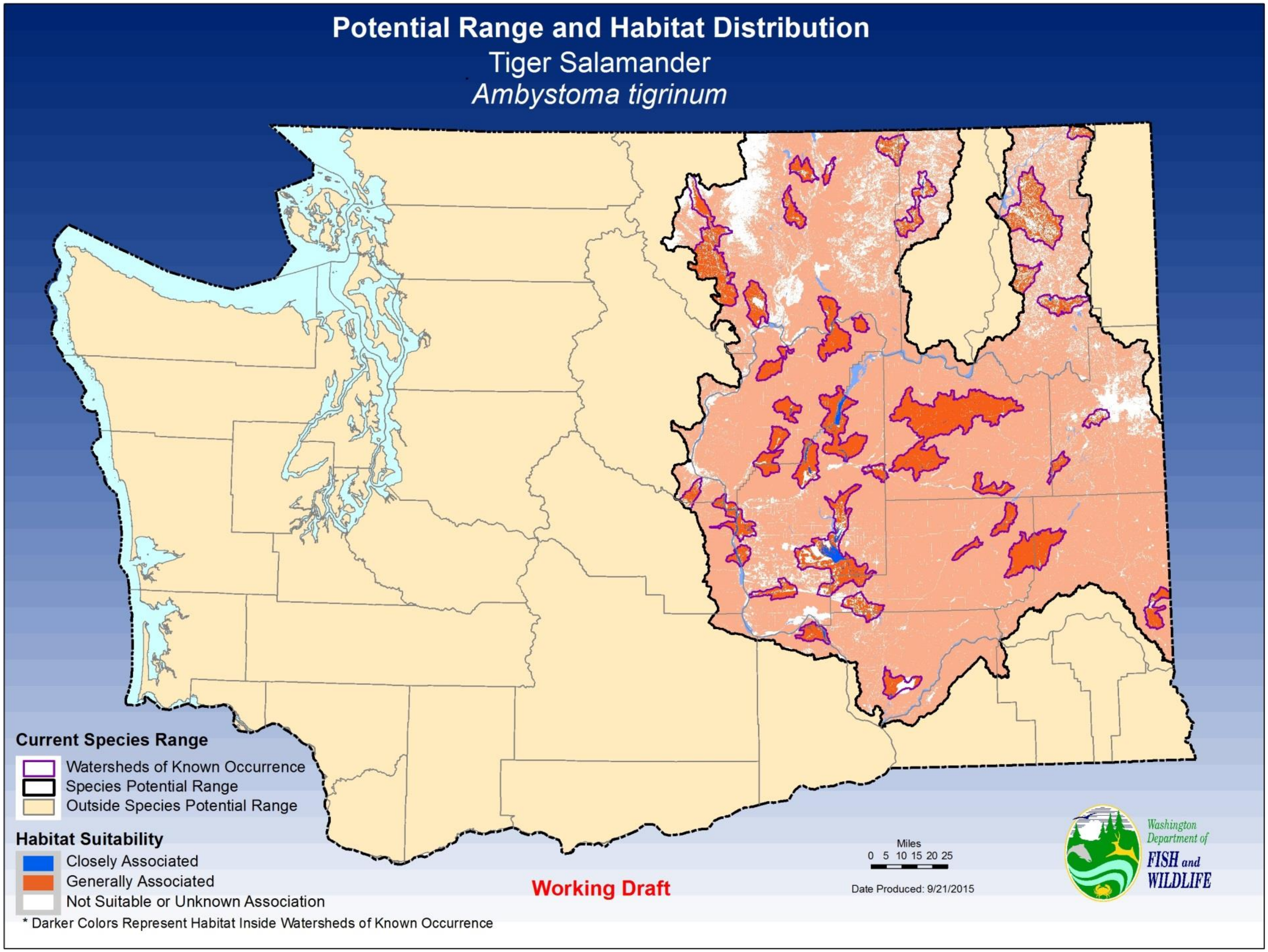
Oregon Spotted Frog



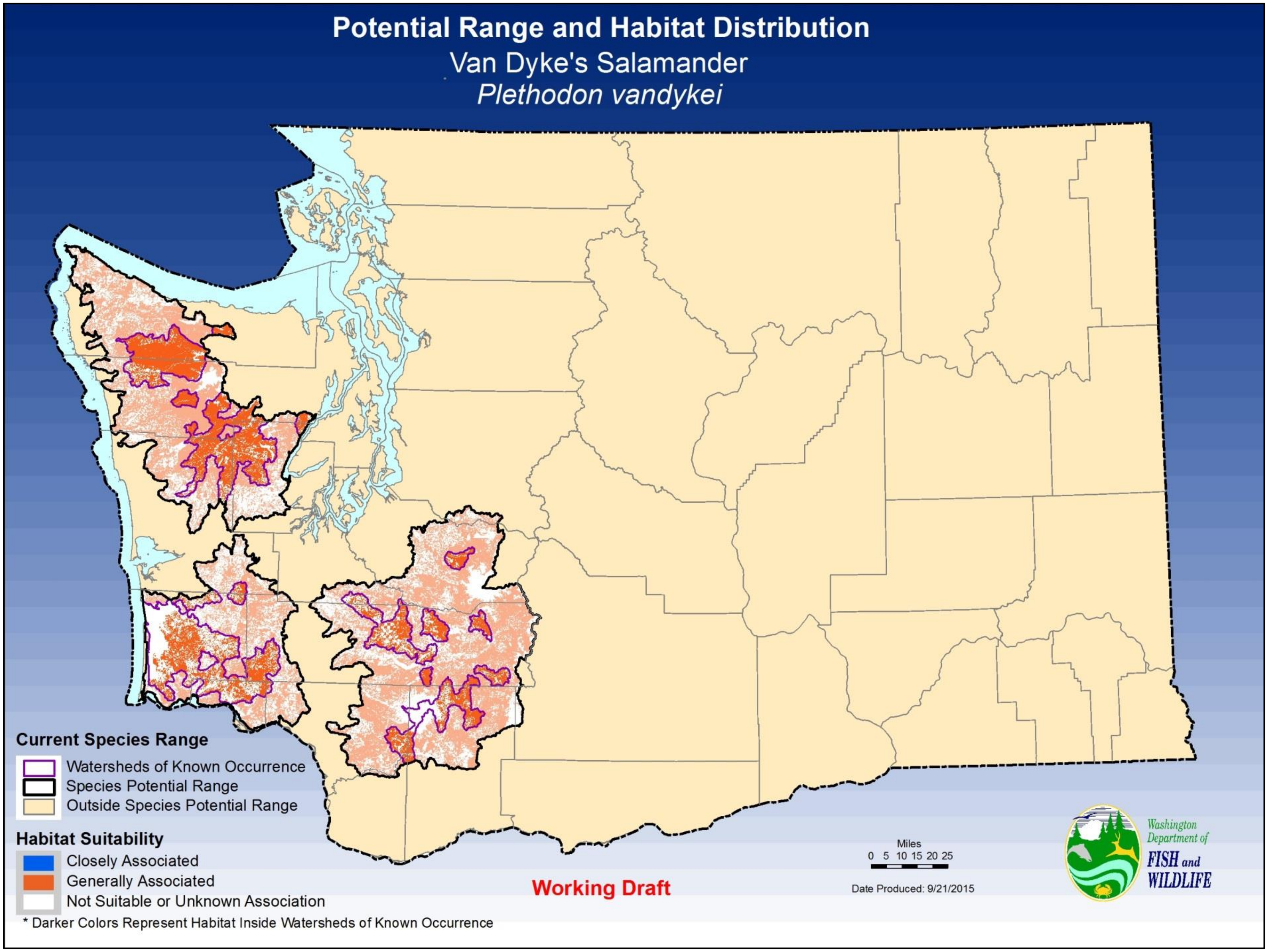
Rocky Mountain Tailed Frog



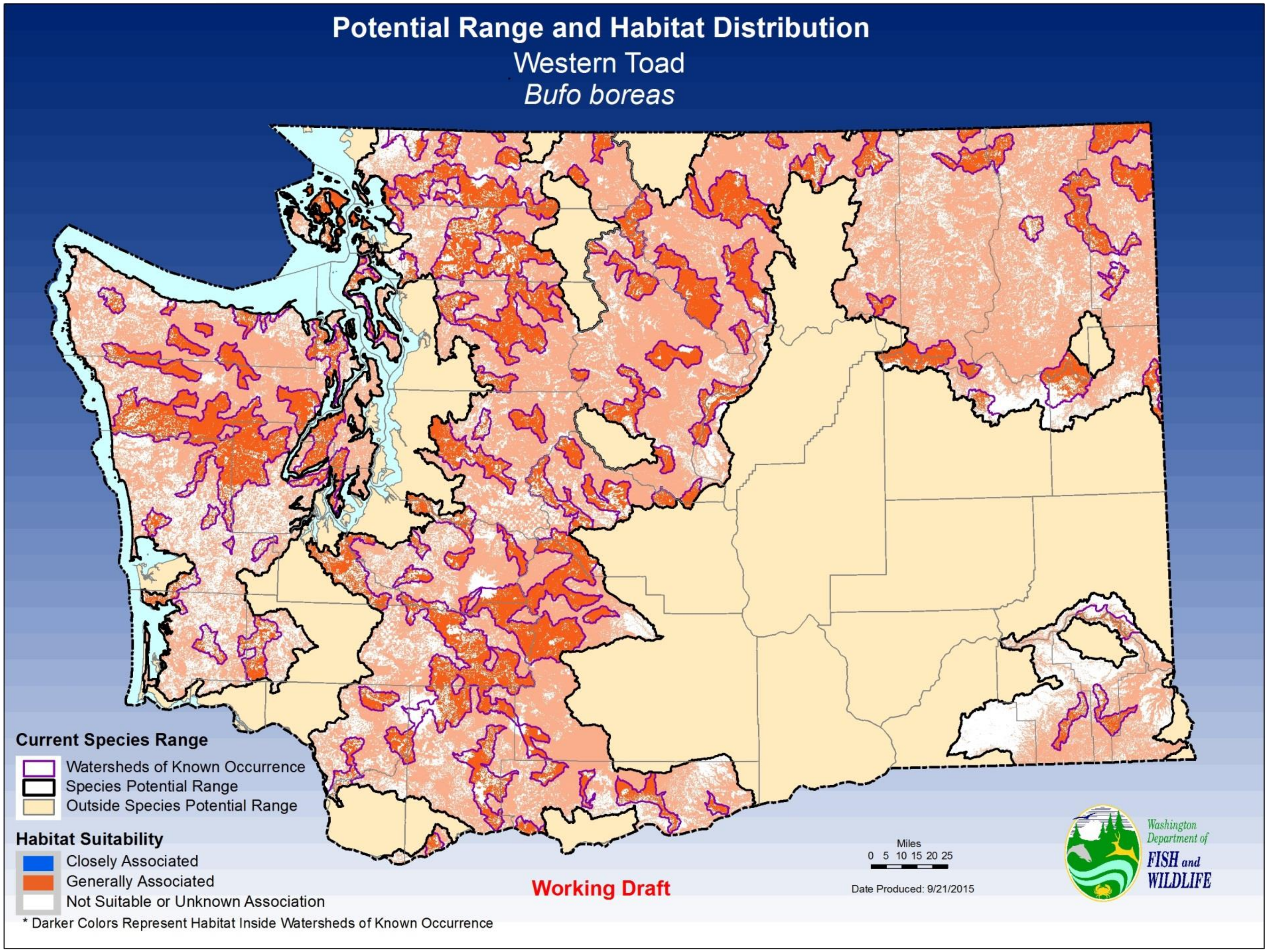
Tiger Salamander



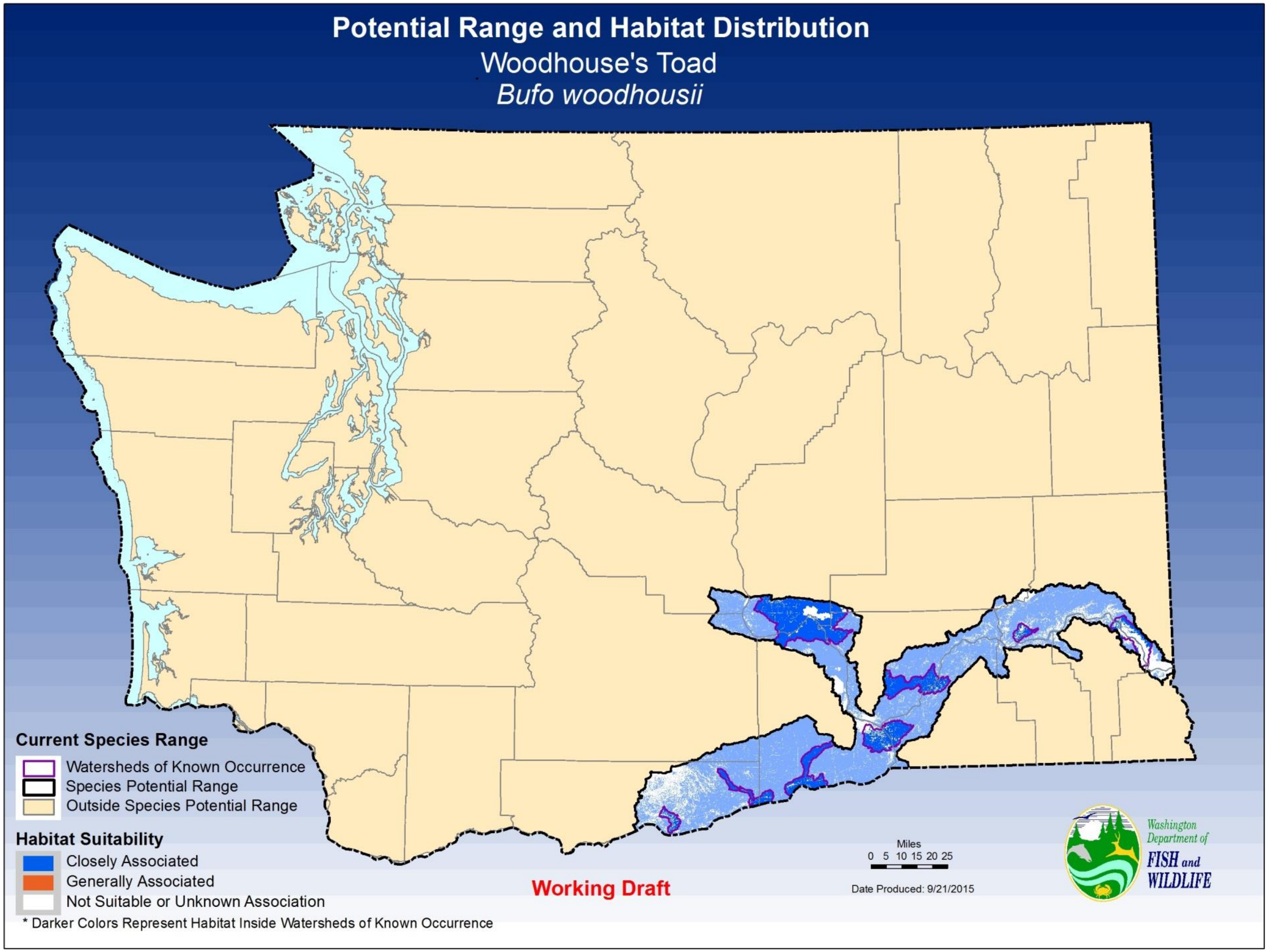
Van Dyke's Salamander



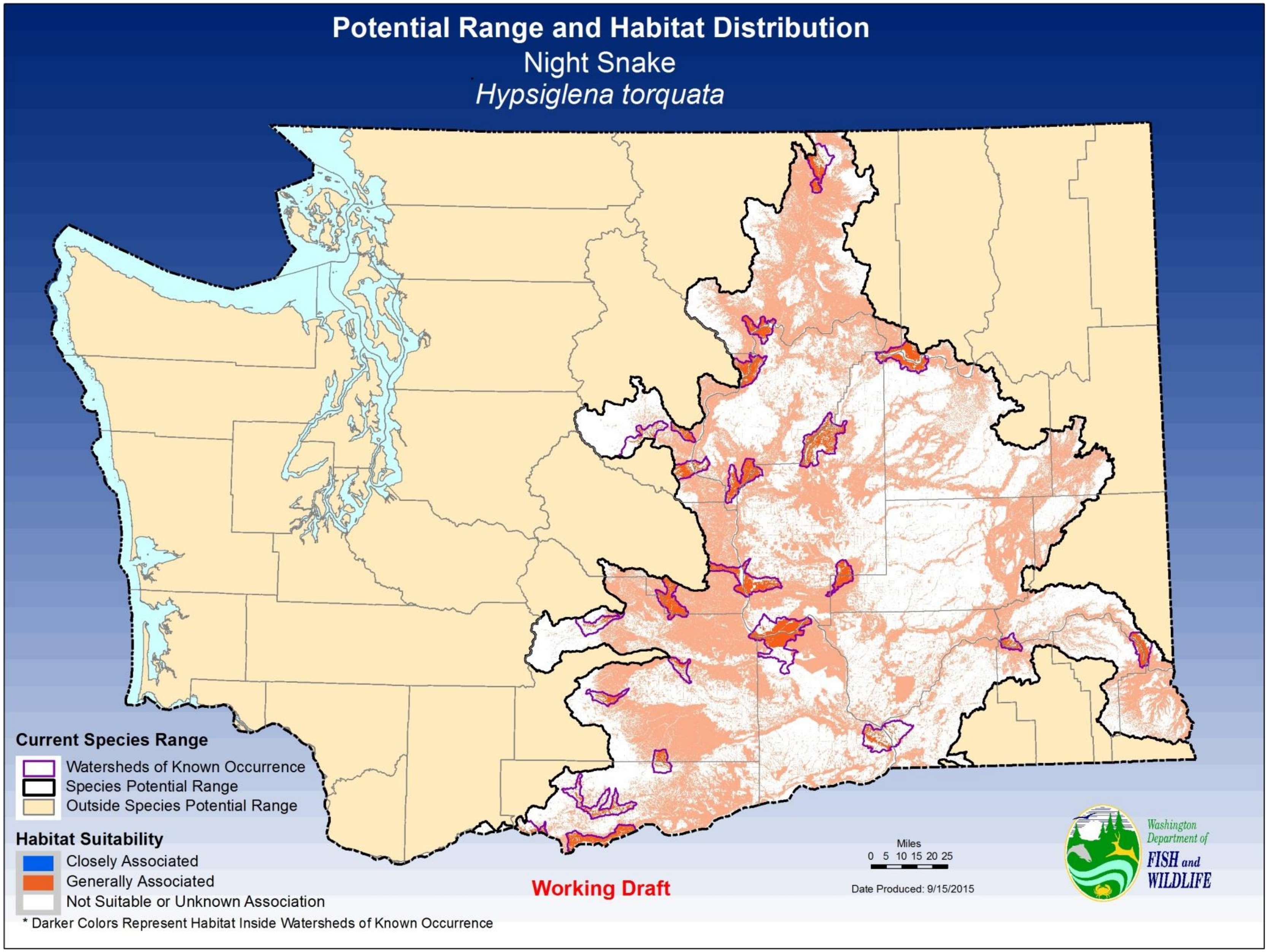
Western Toad



Woodhouse's Toad

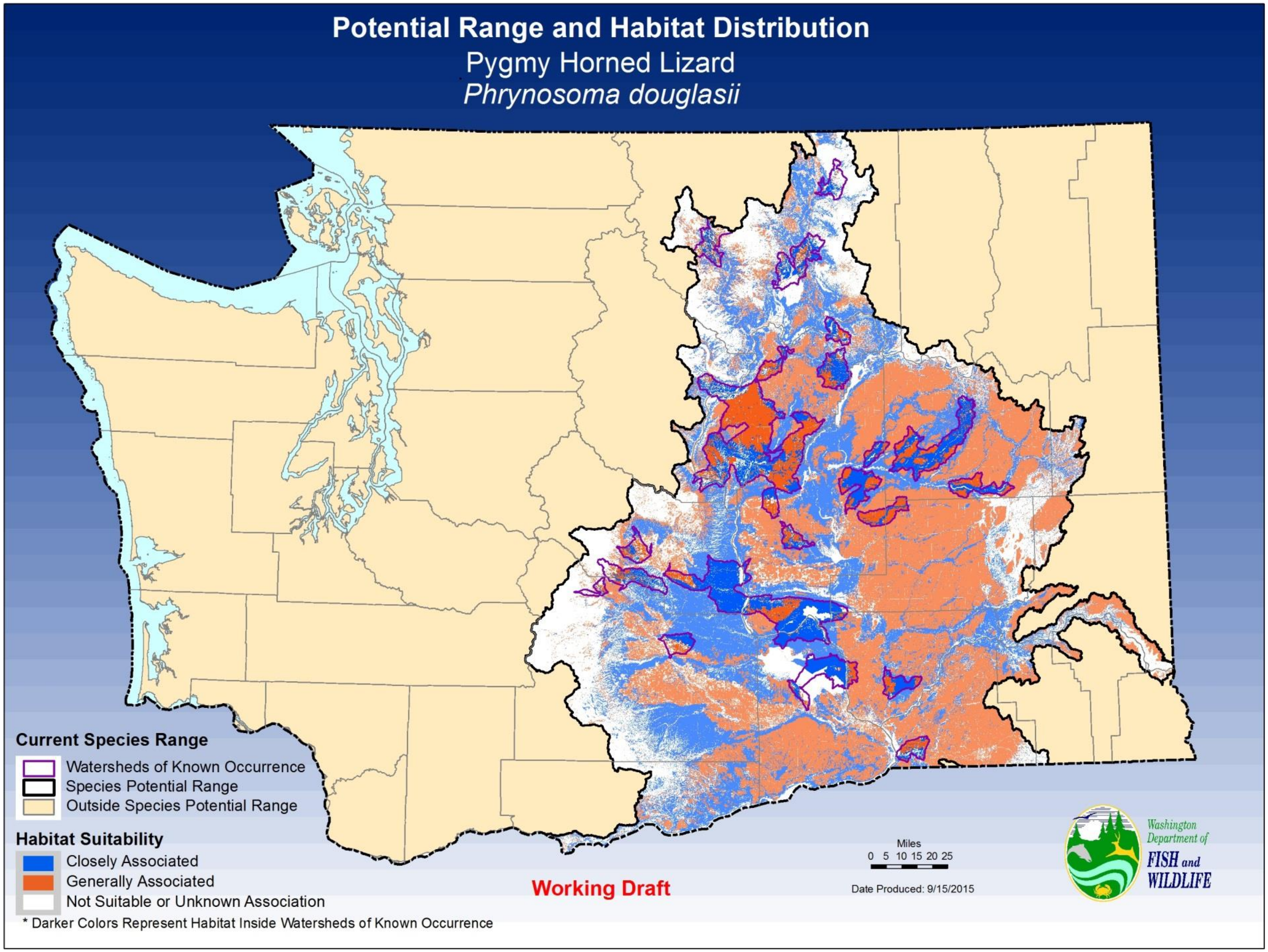


Night Snake

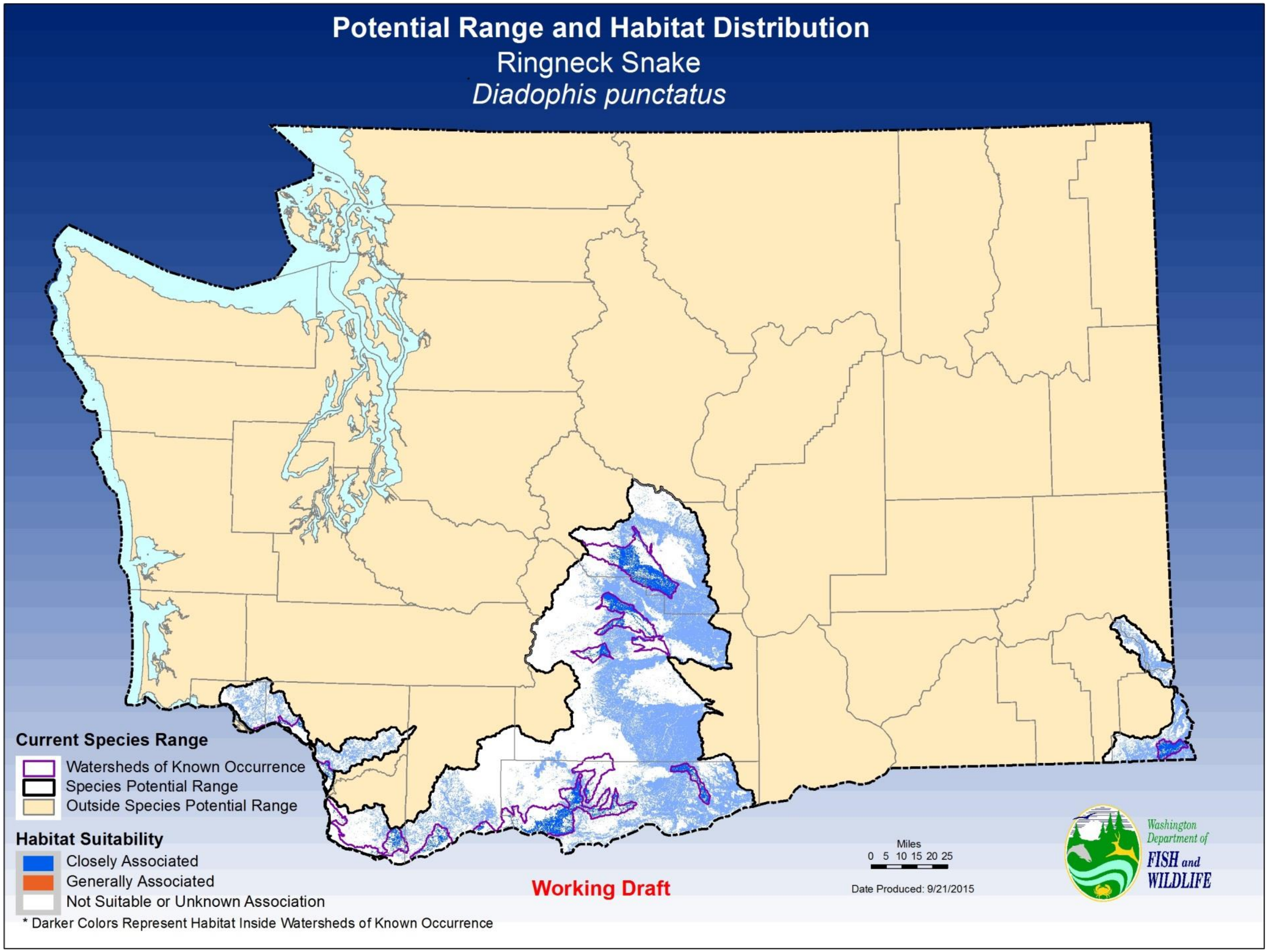


Potential Range and Habitat Distribution
Night Snake
Hypsiglena torquata
Current Species Range
Watersheds of Known Occurrence
Species Potential Range
Outside Species Potential Range
Habitat Suitability
Closely Associated
Generally Associated
Not Suitable or Unknown Association
* Darker Colors Represent 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

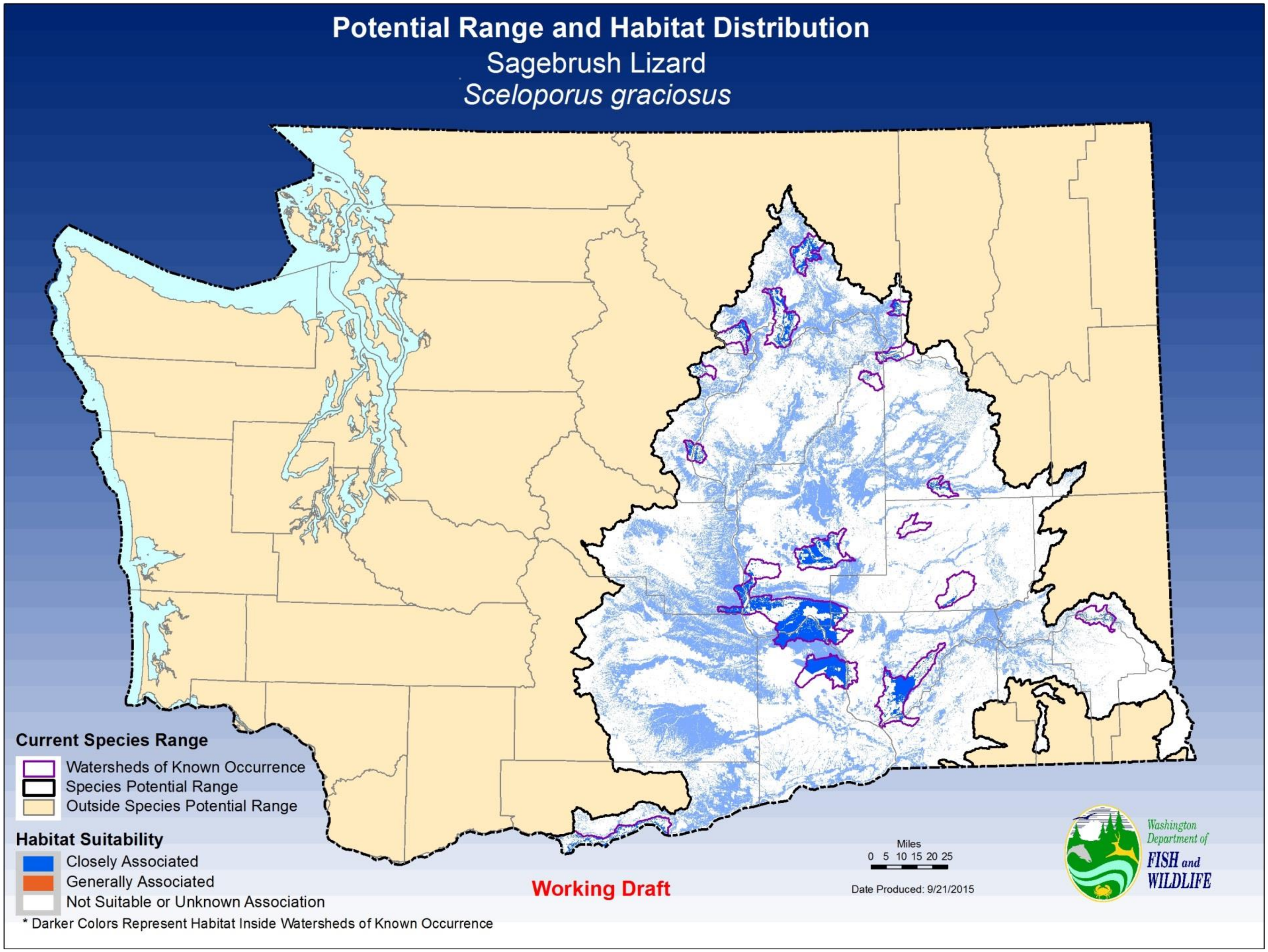
Pygmy Horned Lizard



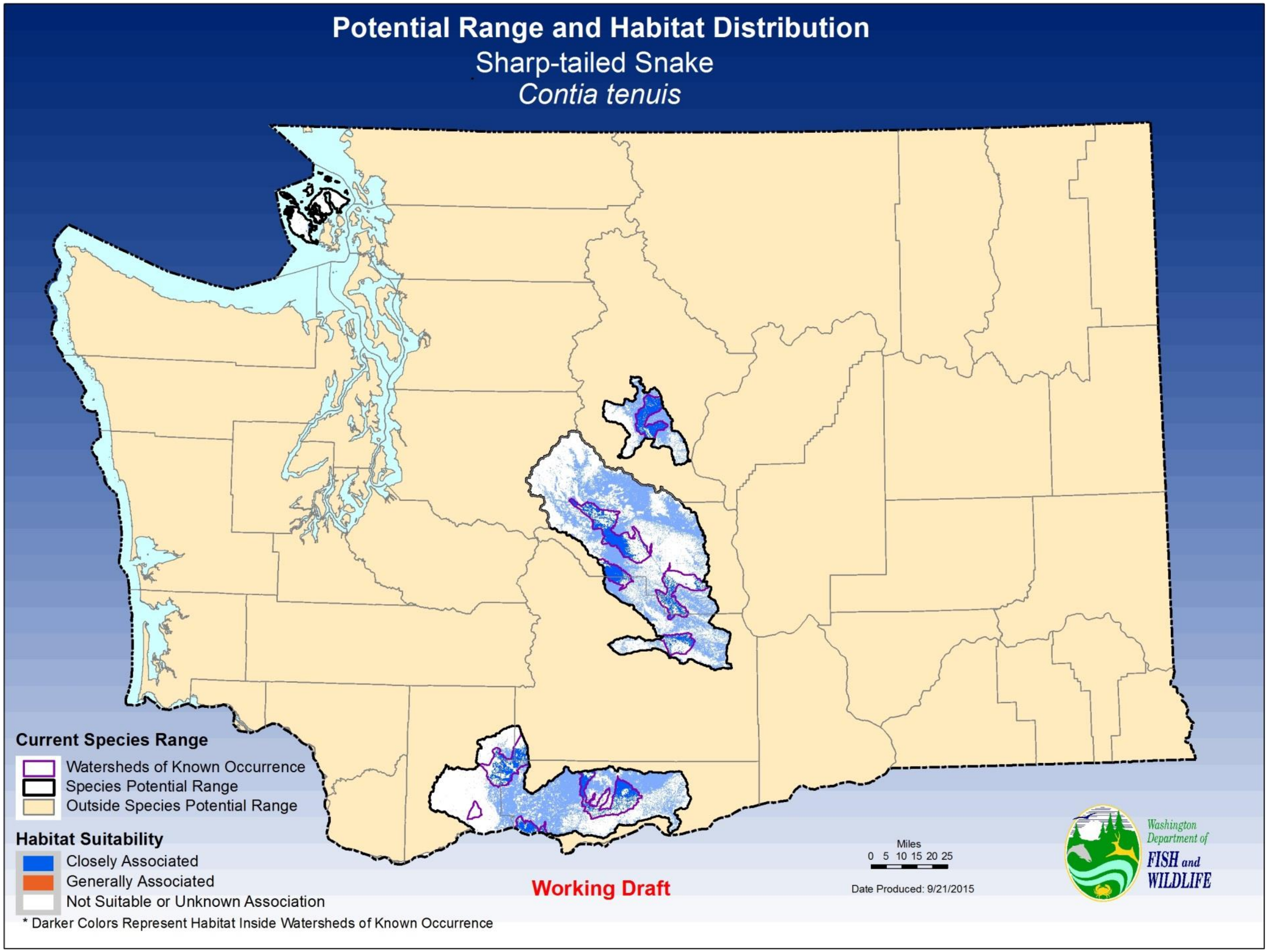
Ringneck Snake



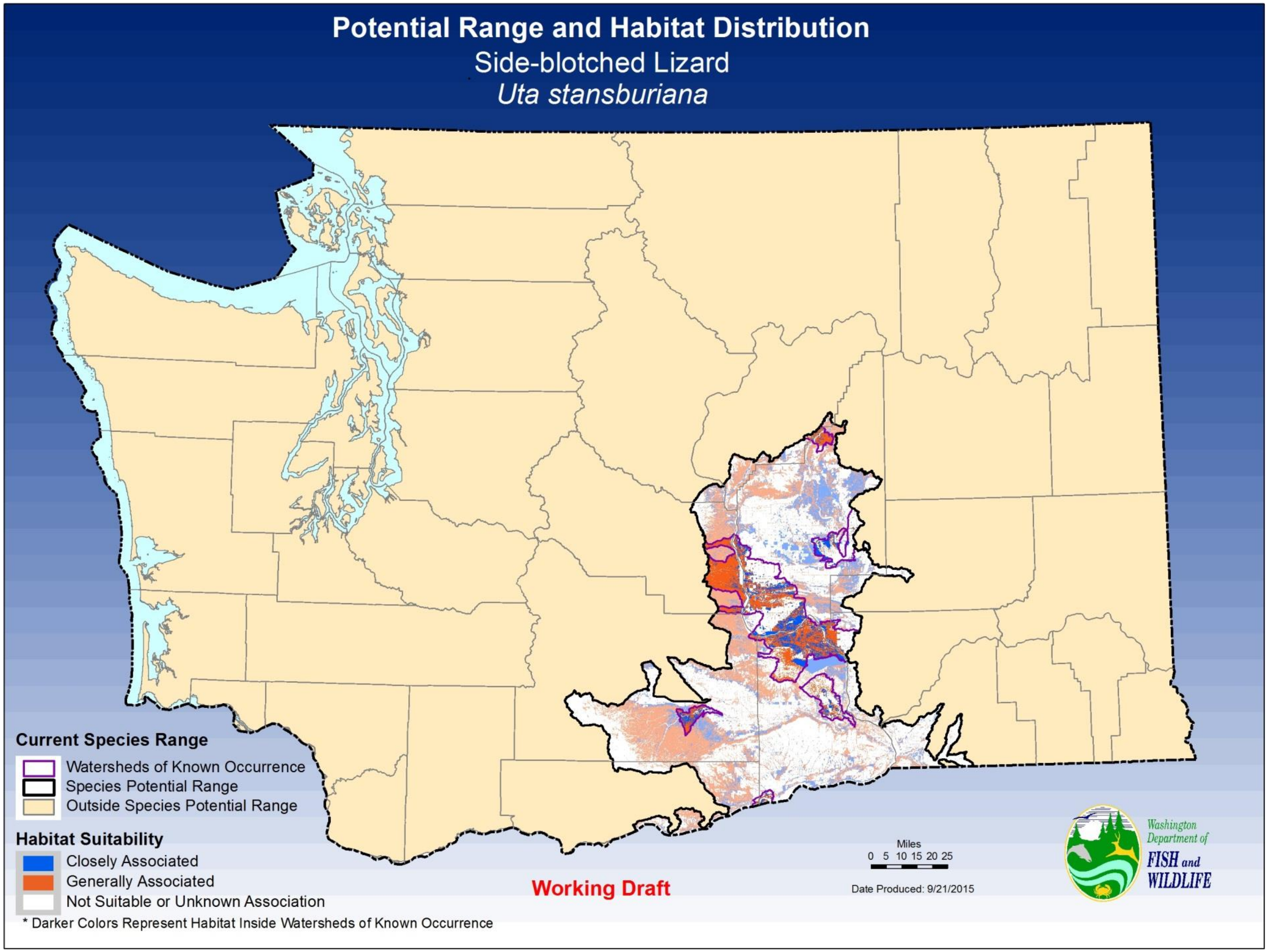
Sagebrush Lizard



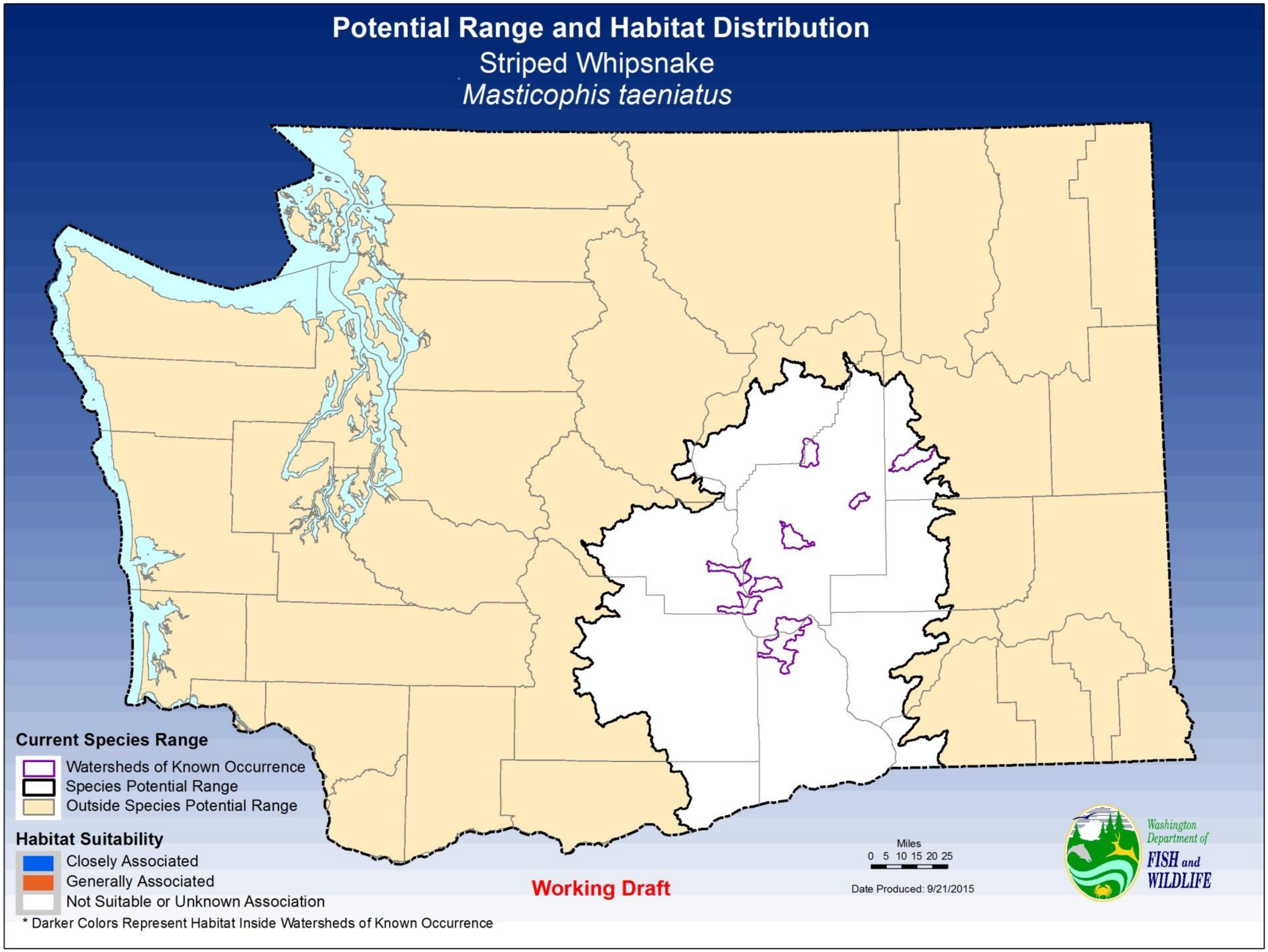
Sharp-tailed Snake



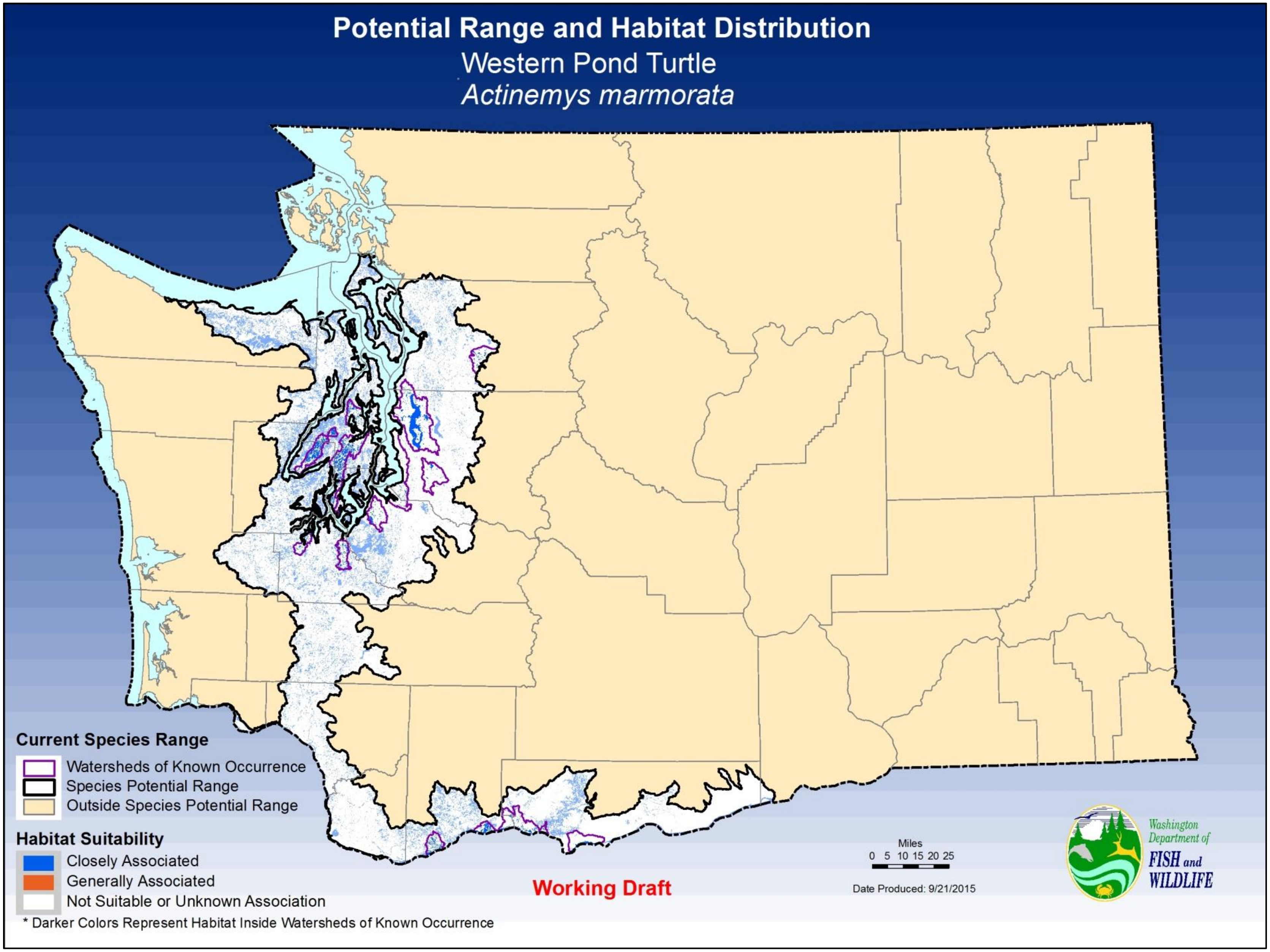
Side-blotched Lizard



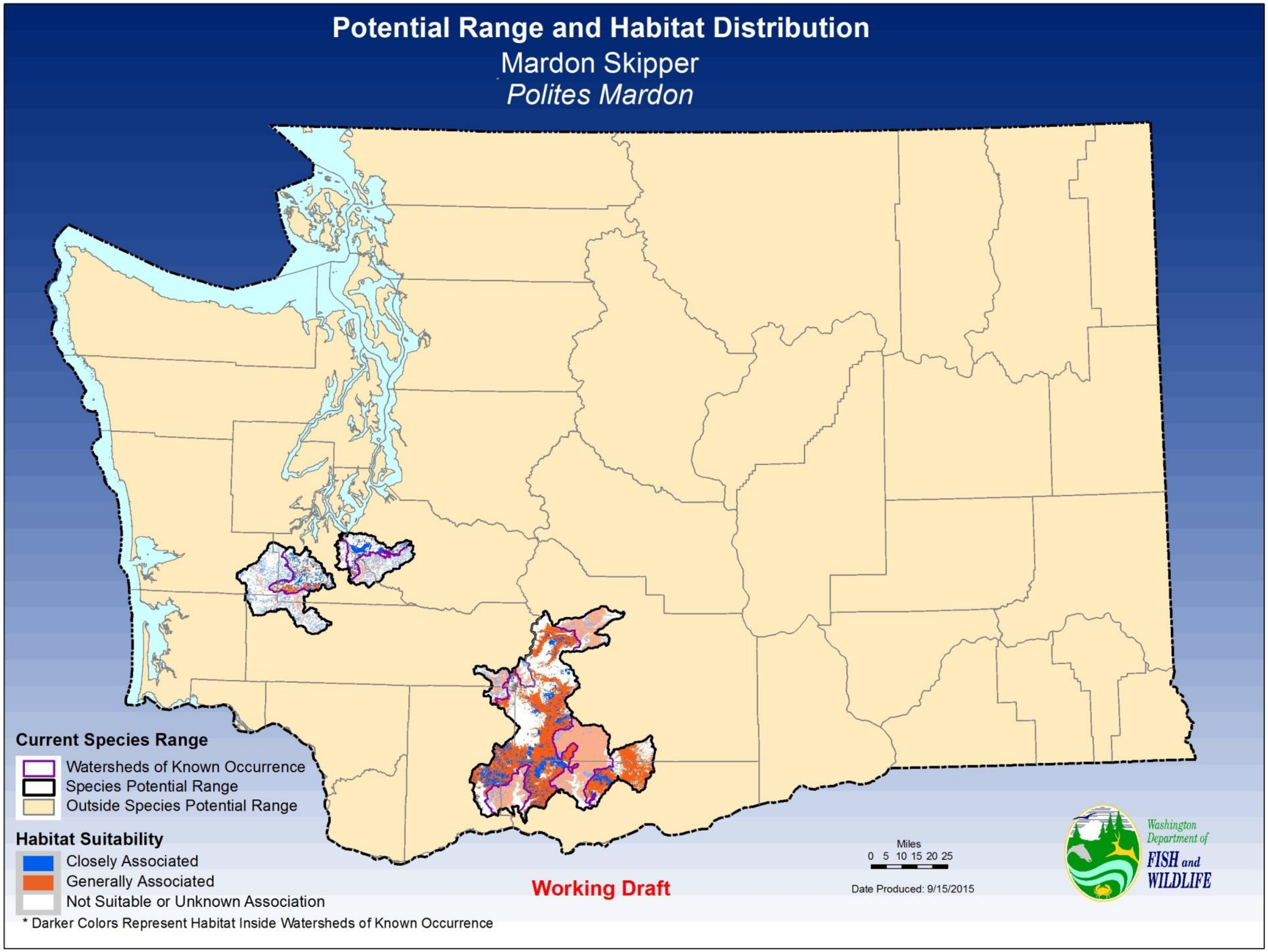
Striped Whipsnake



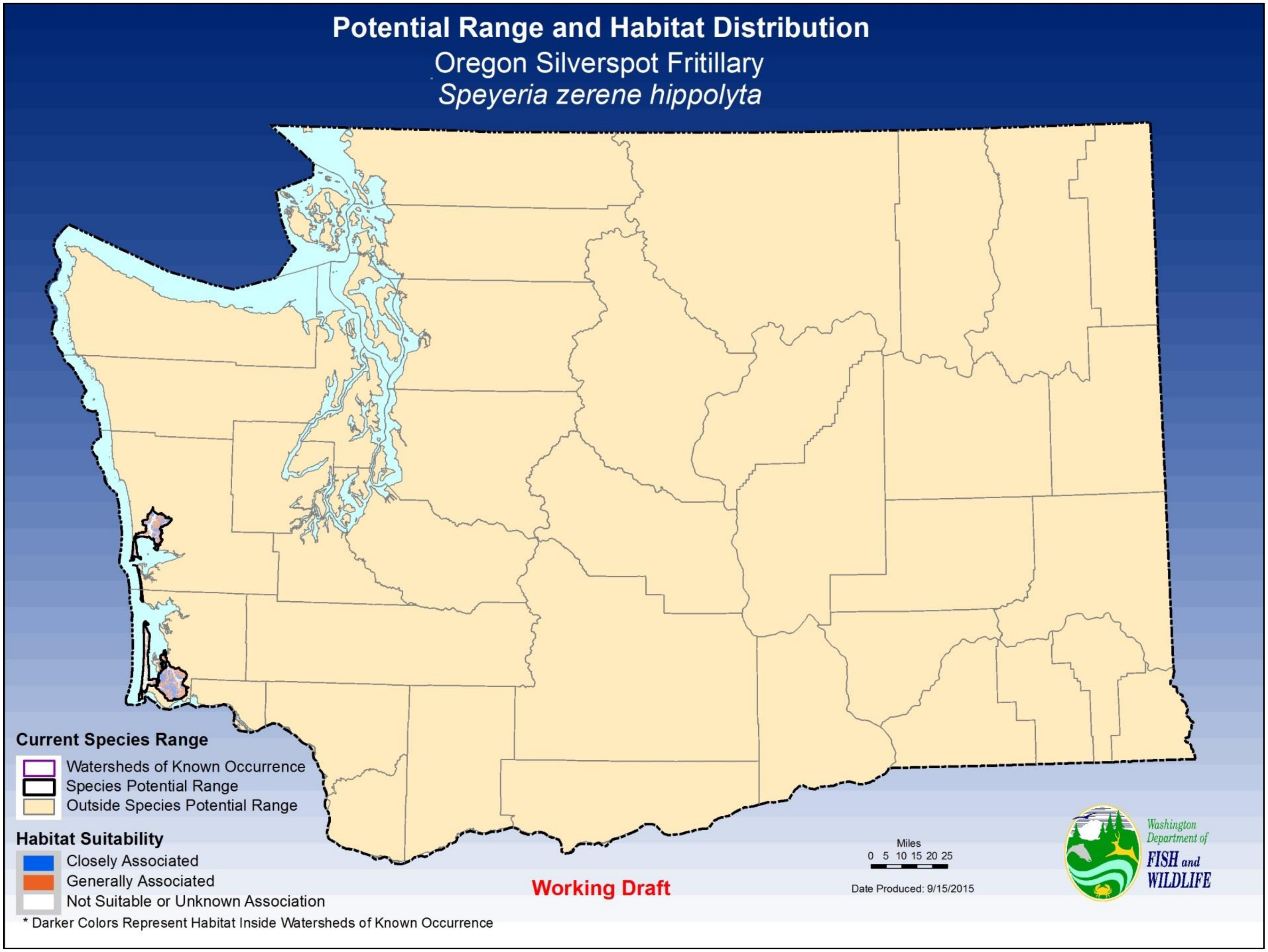
Western Pond Turtle



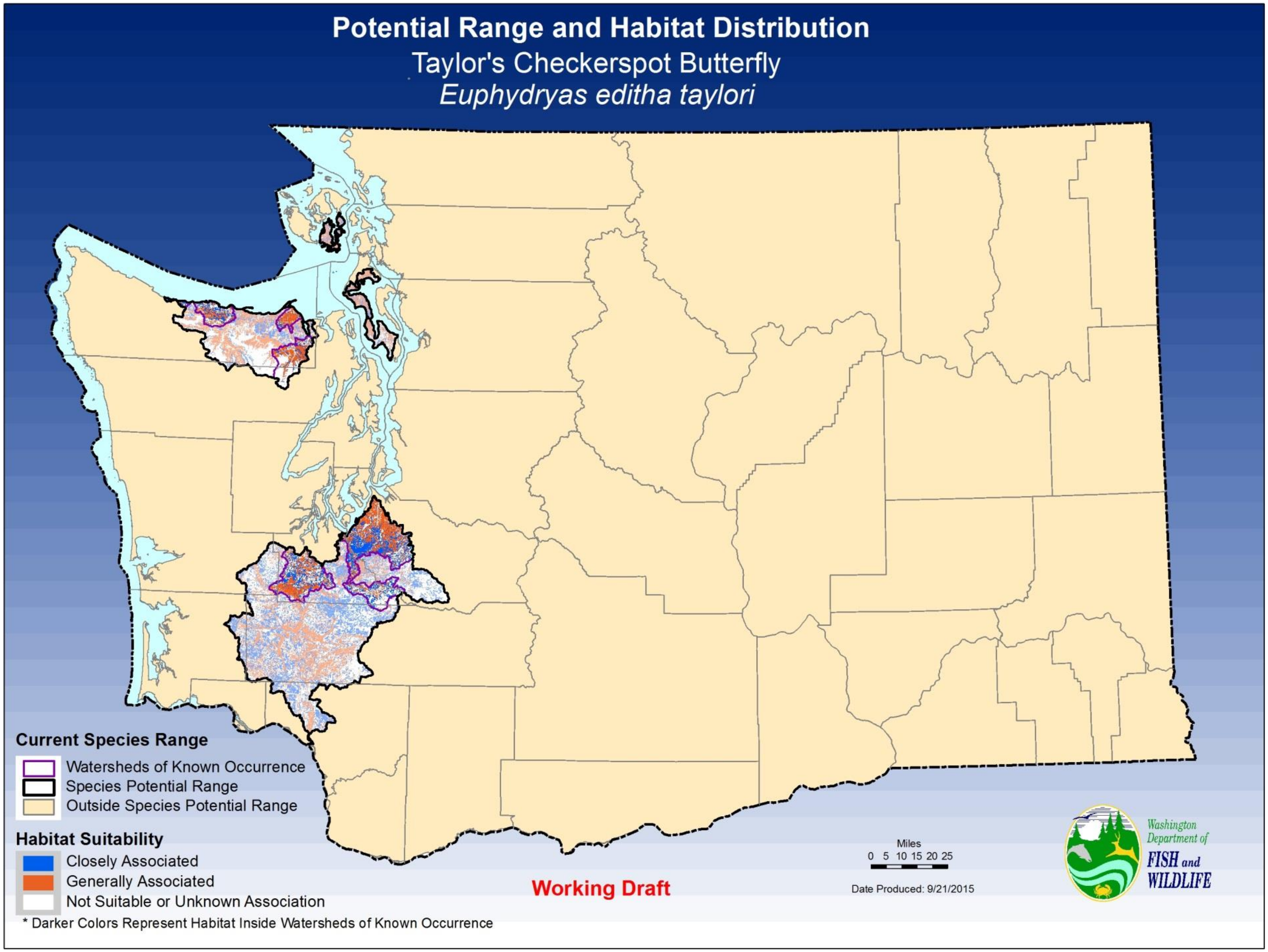
Mardon Skipper



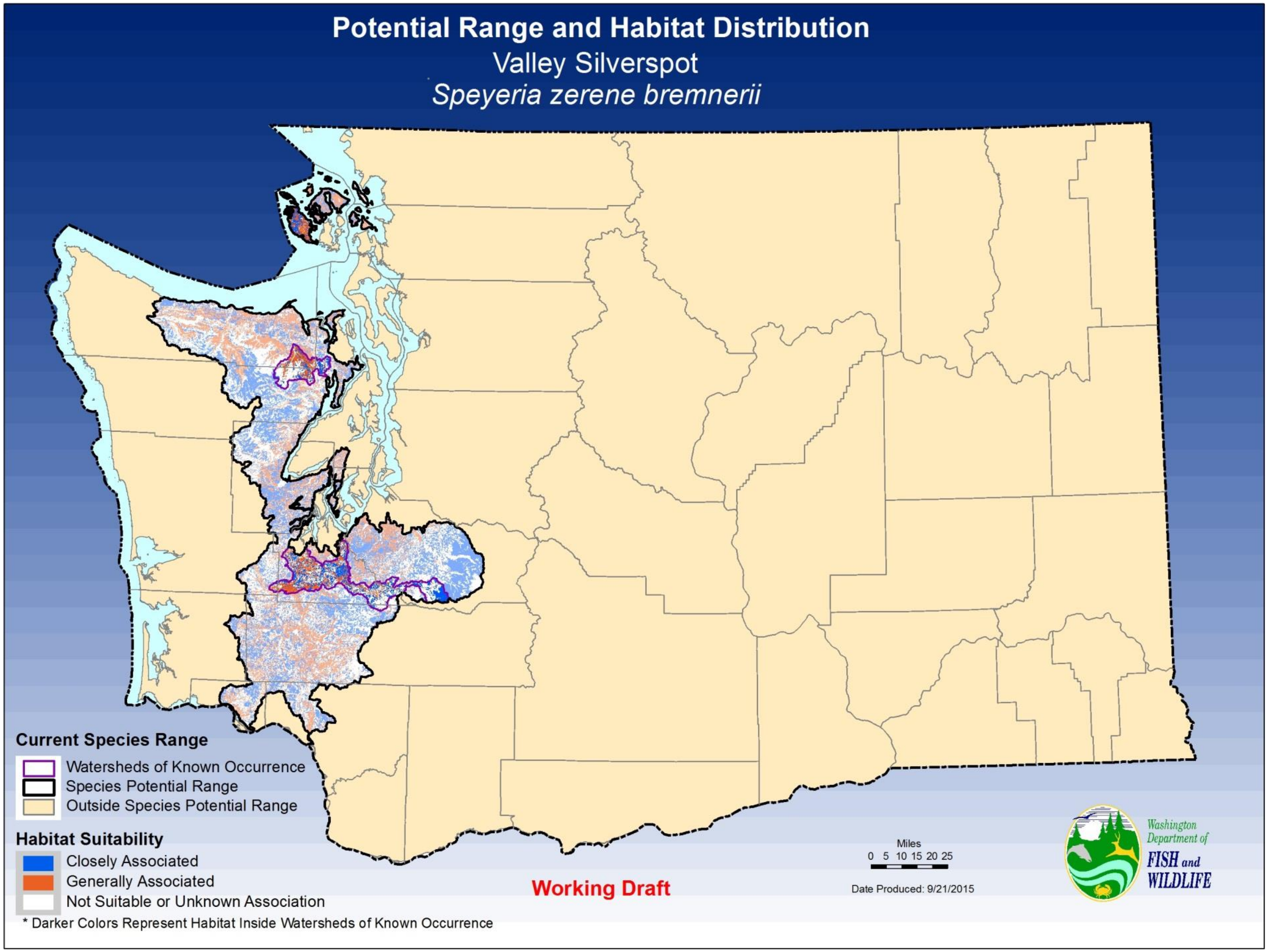
Oregon Silverspot



Taylor's Checkerspot Butterfly



Valley Silverspot



Appendix C

Climate Change: Supporting Information

Table of Contents

LIST OF TABLES

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).

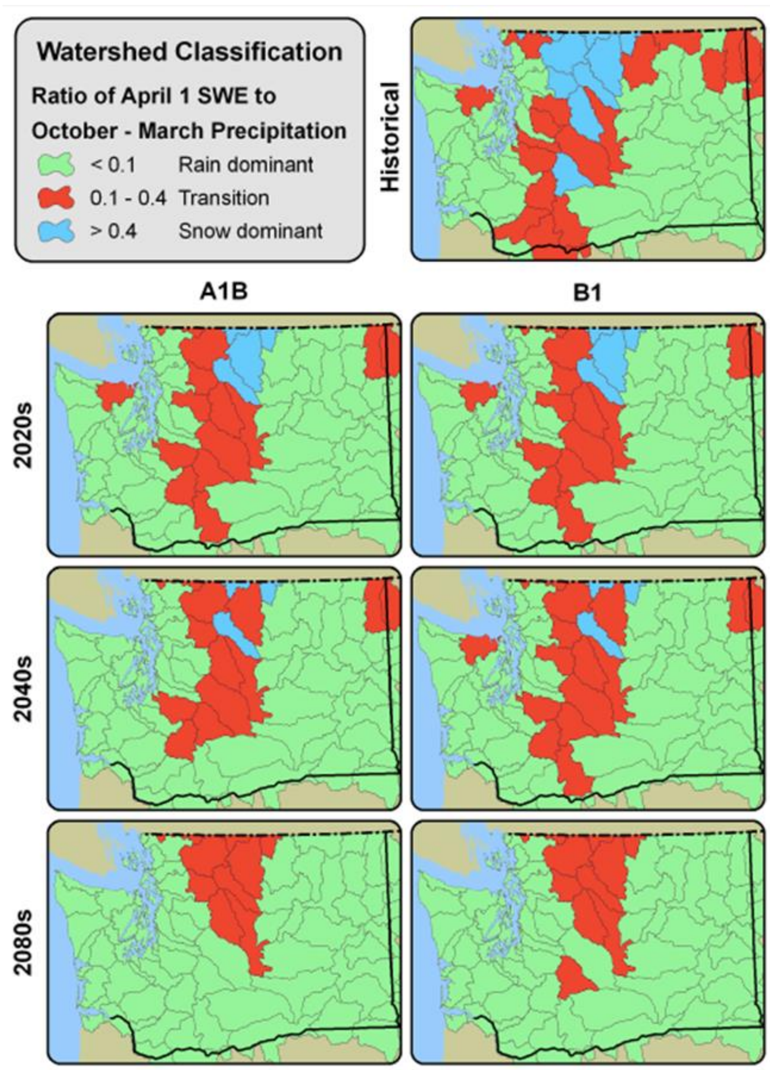


Figure C-1: Watershed Classification Maps

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).

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[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.

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[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

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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

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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.

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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

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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

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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

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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

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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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						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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Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
					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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Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						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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Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
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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Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						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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Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						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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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. 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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Species	**Overall Vulnerability**	**Overall Confidence**	**Sensitivity Rank**	**Exposure Rank**	**Summary of Exposure**	**Summary of Sensitivity**
						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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						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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						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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						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

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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 population s - High Low elevation population s - 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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Appendix D

Stakeholder Engagement and Outreach

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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

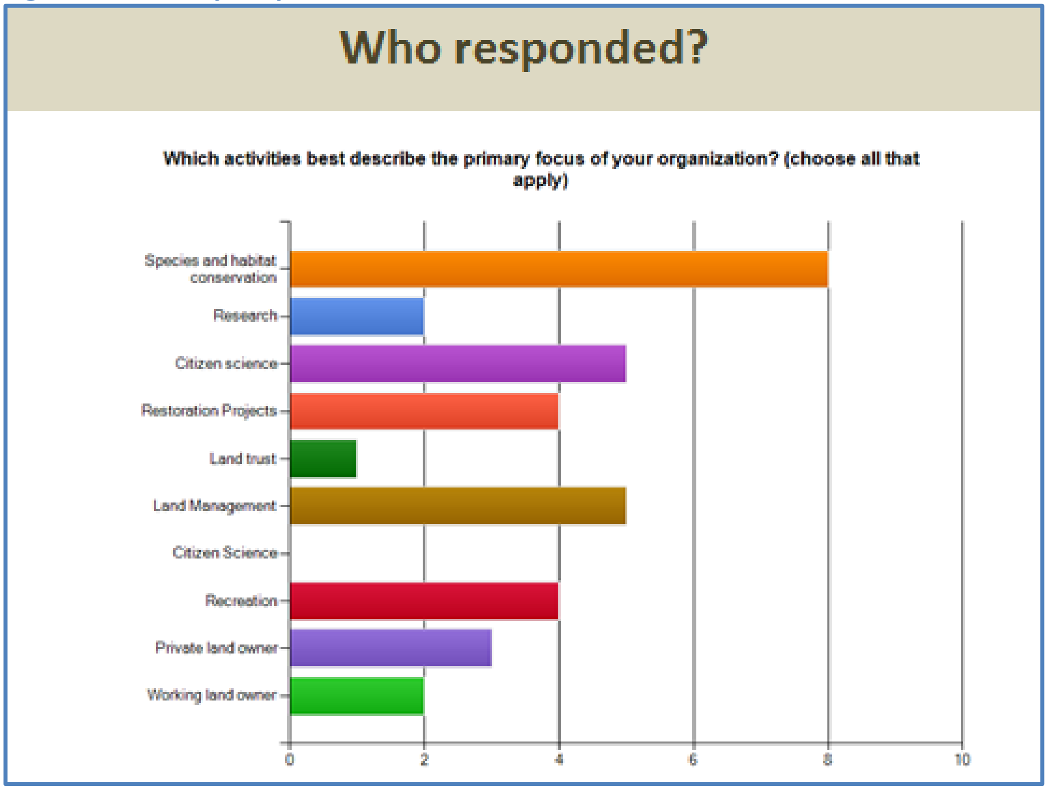
Early in the process we reviewed existing lists from within WDFW to identify individuals, tribes and organizations potentially interested in conservation issues or having specialized expertise or knowledge to contribute. An introductory email was sent to approximately 250 individuals and organizations, 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.

REFERENCE	CHAPTER	CODE
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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

<table>
<tr><th>COMMENT</th><th>RESPONSE</th></tr>
<tr><td>Acknowledge recent habitat acquisitions</td><td rowspan="2">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).</td></tr>
<tr><td>Include additional collaborative projects</td></tr>
</table>

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.	