IRST Amphibian Literature Review – Questions 1-2

DRAFT 11/13/2025

Introduction

This literature review addresses five species anticipated to be covered in the Oregon Private Forestlands HCP: Cope's Giant Salamander (*Dicamptodon copei*), Coastal Giant Salamander (*D. tenebrosus*), Columbia Torrent Salamander (*Rhyacotriton kezeri*), and Southern Torrent Salamander (*R. variegatus*), and Coastal Tailed Frog (*Ascaphus truei*). For this review, we considered research relevant to the AMPC's amphibian questions, with emphasis on: 1) distribution and watershed-scale patterns; 2) genetics and connectivity; 3) local habitat factors such as gradient, temperature, and substrates; 4) population trends for Columbia and Southern Torrent Salamanders; and 5) baseline conditions that can inform monitoring design. Given the AMPC's framing, our review focuses on synthesizing available evidence in these topical areas, rather than comprehensively summarizing all amphibian ecology literature.

<u>Conservation Status in Oregon</u>

Of the five focal amphibian species, four (Dicamptodon copei, Rhyacotriton kezeri, R. variegatus, and Ascaphus truei) are designated by the Oregon Department of Fish and Wildlife (ODFW) as both Sensitive Species and Species of Greatest Conservation Need (SGCN). The Coastal Giant Salamander (Dicamptodon tenebrosus) is not currently included under these designations. The Oregon Biodiversity Information Center (ORBIC) state ranks further reflect species-specific rarity, vulnerability, and threats related to habitat specificity, hydrologic dependence, and sensitivity to forest practices. These designations provide important context for interpreting habitat relationships, potential research priorities, and conservation needs across landownerships (Table 1). These rankings should inform both the spatial scale and thematic emphasis of future monitoring and modeling efforts. Particularly for species ranked S1–S2 (R. kezeri, R. variegatus, D. copei), there is strong justification for focused evaluation of population persistence and habitat protections under current and proposed forest practices.

Table 1. ODFW Sensitive Species designations, Oregon Conservation Strategy inclusion, and ORBIC state ranks for the five focal amphibian species. These conservation statuses reflect vulnerability to habitat alteration, hydrologic dependence, and forest management impacts, and inform prioritization of future monitoring or modeling efforts under the Private Forest Accord.

Species	ODFW Sensitive Species Listing*	OR Conservation Strategy Species	ORBIC Rank (Oregon)	Rationale Summary
Cope's Giant Salamander (*Dicamptodon copei*)	Coast Range, West Cascades, East Cascades	Yes	S2 (Imperiled)	Restricted range; patchy occupancy; sensitivity to canopy loss and sedimentation

Species	ODFW Sensitive Species Listing*	OR Conservation Strategy Species	ORBIC Rank (Oregon)	Rationale Summary
Coastal Giant Salamander *(Dicamptodon tenebrosus*)	n/a	No	S3 (Vulnerable)	Broad range; localized declines; sedimentation and hydrology impacts
Columbia Torrent Salamander (*Rhyacotriton kezeri*)	Coast Range	Yes	S1 (Critically Imperiled)	Narrow range; hydrologic dependence; habitat fragmentation
Southern Torrent Salamander (*Rhyacotriton variegatus*)	Coast Range, West Cascades	Yes	S2 (Imperiled)	Headwater specialist; sensitive to stream temperature and canopy loss
Coastal Tailed Frog *(Ascaphus truei*)	Coast Range, West Cascades	Yes	S3 (Vulnerable)	Low mobility; sedimentation- and buffer-sensitive; slow recolonization

Four of these species were summarized in Sensitive Species accounts prepared by the Institute for Natural Resources (INR) for the Oregon Department of Fish and Wildlife in 2023, which provide baseline information on distribution, habitat, and management considerations. Sources for this review include the Sensitive Species accounts, occurrence records managed in the Biotics database, and peer-reviewed and gray literature (particularly 2023–present publications). Information is organized by topical area with species subsections, highlighting consistencies and differences across taxa.

Distribution

Understanding the geographic distribution of the five focal amphibian species is essential for assessing conservation status, identifying potential management impacts, and designing monitoring relevant to the Forest Practices Act. The AMPC emphasized the need to characterize distribution at watershed scales (e.g., HUC-10 or finer, 200-500 km^2) and to evaluate confidence in existing data. Hydrologic Unit Codes (HUCs) are standardized watershed delineations developed by the U.S. Geological Survey; HUC-12 represents the sub-watershed scale (~10–40 km^2).

Basic statewide species distribution models for most vertebrate species have been developed by the INR Oregon Biodiversity Information Center at Portland State University working with the Oregon Department of Fish and Wildlife (ODFW). These models are based on expert judgment ratings of the suitability of each of 76 mapped habitat types for each species. habitat suitability ratings were as follows:

- 0 - not suitable habitat for that species
- 1 - poor or infrequently used habitat for that species
- 2 - suitable (fair) habitat for that species
- 3 - good habitat for that species (good or excellent habitat)

The habitat map was based on 2016 satellite imagery (INR 2018). Habitat was constrained to HUC-12 watersheds with known or probable species occurrences. A partial example of these habitat associations for the Southern Torrent Salamander (*Rhyacotriton variegatus*) is provided below:

Habitat	Value
Burns	1
Cliffs and Canyons	2
Coastal and Valley Riparian	2
Coastal Spruce, Cedar or Redwood mature	3
Coastal Spruce, Cedar or Redwood medium	3
Coastal Spruce, Cedar or Redwood old-growth	3
Coastal Spruce, Cedar or Redwood young	3
Douglas Fir - Western Hemlock mature	3
Douglas Fir - Western Hemlock medium	3
Douglas Fir - Western Hemlock old-growth	3
Douglas Fir - Western Hemlock young	3
Early Shrub-Tree	1
Mixed Hardwood - Conifer mature	3
Mixed Hardwood - Conifer medium	3
Mixed Hardwood - Conifer old-growth	3

Historic pre-settlement habitat distributions have also been derived from the Oregon Gap Analysis Project (*Kagan et al*. 1999), which combined early vertebrate range hexagons, a species–habitat relationship matrix, and a reconstructed historic vegetation map (INR 2005).

For the purposes of this review, distributional confidence is interpreted more broadly than the rule-level scores used within the INR models. It reflects not only model reliability, but also the recency, spatial coverage, and consistency of information from peer-reviewed studies, agency reports, and other available data sources:

- *High* – supported by recent, range-wide field or occupancy data with direct validation of habitat associations; INR model layers are used only as contextual background;
- *Moderate* – supported by INR models or regional datasets that provide reasonable spatial coverage but lack formal validation or recent field corroboration;
- *Low* – based primarily on historical records, sparse detections, or unvalidated, coarse model predictions with little external evidence.

Cope's Giant Salamander (*Dicamptodon copei*)

Range and Counties: Restricted to two disjunct regions: (1) the northern Coast Range south to the Nehalem River, and (2) Cascades south to the upper White River in Hood River and Wasco County (Nussbaum 1970; Adams & Bury 2002; Foster & Olson 2014). County records from ORBIC (2019) include Clackamas, Clatsop, Columbia, Hood River, Multnomah, Tillamook, Wasco, and Washington.

Elevation: Recorded from ~5 m in Washington to 1,593 m in Oregon, with mean ~475 m (Adams & Bury 2002; Foster & Olson 2014).

Modeling: INR models (2005 vs. 2019) show contraction relative to historic distributions. Kagan et al. (1999) estimated ~19.6% reduction in suitable habitat between 1851 and the 1990s. Current INR outputs also summarize ownership patterns of predicted habitat (INR 2005, 2019).

Confidence: *Moderate*. INR habitat models align with known county-level records and general ecoregional boundaries, providing a reliable statewide baseline. Fine-scale occupancy and population structure remain poorly resolved, and no recent validation or demographic data are available.
Gaps: No statewide occupancy models; limited data on elevational limits and ecoregional variation.

Coastal Giant Salamander (*Dicamptodon tenebrosus*)

Range and Counties: Distributed across the Coast Range, Cascades, and Klamath Mountains (Nussbaum 1976; Good & Wake 1992; Olson & Weaver 2007). Overlaps with *D. copei* in the northern Coast Range and Cascades but extends farther south. County records (ORBIC 2019) include Benton, Clackamas, Clatsop, Columbia, Coos, Curry, Douglas, Jackson, Josephine, Lane, Lincoln, Linn, Marion, Multnomah, Polk, Tillamook, Washington, and Yamhill.

Elevation: Found from near sea level to ~1,800 m (Good & Wake 1992; Bury et al. 1991).

Modeling: No INR account or recent statewide habitat model exists. Distribution is described through county-level records and regional surveys (ORBIC 2019; Bury et al. 1991; Olson & Weaver 2007).

Confidence: *Low to Moderate.* Distribution is well documented from extensive occurrence records, but no INR habitat model or statewide analysis exists, and no recent field validation has been conducted.

Gaps: Although recent genetic and field investigations exist for *D. tenebrosus* in Oregon (Auteri et al. 2022; Neal et al. 2024), watershed-scale predictive models remain limited, and demographic time-series, effective population size estimates, and spatially exhaustive occupancy surveys are still lacking

Columbia Torrent Salamander (*Rhyacotriton kezeri*)

Range and Counties: Endemic to the northern Oregon Coast Range, from southwestern Washington south to the Little Nestucca River in Polk County (Good & Wake 1992; Rundio & Olson 2001; Steele et al. 2003; Olson & Ares 2022). Counties include Clatsop, Columbia, Tillamook, Washington, Yamhill, and Polk (ORBIC 2019).

Elevation: Generally occurs below ~1,000 m in montane headwaters (Steele et al. 2003; Russell et al. 2004).

Modeling: INR habitat models (2005 vs. 2019) show contraction relative to historic distributions. Kagan et al. (1999) estimated substantial losses of suitable habitat (~66%) since Euro-American settlement, including major reductions in riparian and coniferous forests of the northern Coast Range. INR projections indicate continued vulnerability to fragmentation, particularly on private lands (INR 2005, 2019). Recent range-wide occupancy surveys and boosted regression tree habitat-suitability models (Thurman et al. 2025) provide watershed- and reach-scale predictions. *R. kezeri* was detected at 72% of surveyed sites, with mean counts ≈ 12 individuals per person-hour, and field counts positively correlated with modeled suitability. Key predictors included slope, summer moisture balance, variability in actual evapotranspiration, baseflow and streamflow permanence, canopy cover, and moderate tree volume. These models generate HUC12- and 30 m-scale layers that can identify potential climate refugia and priority watersheds for monitoring (Thurman et al. 2025).

Confidence: *High*. Recent statewide modeling and occupancy surveys (Thurman et al. 2025) provide validated watershed- and reach-scale predictions, supported by strong field detection data and consistent habitat relationships across the range.
Gaps: Genetic sampling still sparse; few long-term demographic datasets.

<u>Southern Torrent Salamander (*Rhyacotriton variegatus*)</u>

Range and Counties: Found in the Coast Range, Klamath Mountains, West Cascades, and marginally in the Willamette Valley (Good & Wake 1992; Wagner et al. 2006; Olson & Ares 2022). Counties include Benton, Coos, Curry, Douglas, Josephine, Lane, Lincoln, Polk, Tillamook, and Yamhill (ORBIC 2019). A disjunct block occurs in the central West Cascades (Douglas and Lane), abutting *R. cascadae* but with no evidence of hybridization (Good & Wake 1992; Wagner et al. 2006).

Elevation: Occurs from near sea level to ~1,469 m, with most populations in cool montane headwaters (Good & Wake 1992; Welsh & Lind 1996).

Modeling: INR models (2005 vs. 2019) depict contraction of predicted habitat relative to historic conditions. Kagan et al. (1999) estimated substantial losses of suitable habitat since Euro-American settlement, including extensive declines in riparian forest of the Coast Range and Klamath Mountains. INR outputs highlight continued vulnerability to fragmentation on non-federal lands (INR 2005, 2019).

Confidence: *Moderate*. INR models and regional field studies provide good spatial coverage but are dated and lack formal validation. Distribution boundaries are reasonably well defined, though current occupancy remains uncertain.
Gaps: No recent occupancy modeling; limited information on current range boundaries.

<u>Coastal Tailed Frog (*Ascaphus truei*)</u>

Range and Counties: Occurs in the Coast Range, West Cascades, East Cascades (scattered records), and Klamath Mountains ecoregions. County records include Benton, Clackamas, Clatsop, Coos, Columbia, Curry, Deschutes, Douglas, Hood River, Jackson, Jefferson, Josephine, Klamath, Lane, Lincoln, Linn, Marion, Multnomah, Polk, Tillamook, Wallowa, Wasco, Washington, Wheeler, and Yamhill (ORBIC 2019). The Wallowa record may represent *A. montanus* rather than *A. truei*, and some eastern Cascade records may also require genetic verification.

Elevation: Found from near sea level to nearly 2,000 m, with detections of recently metamorphosed juveniles more frequent at higher elevations, likely reflecting longer larval development times and cooler, more stable hydrologic conditions in montane streams (Hayes & Quinn 2015; WA Herp Atlas 2017).

Modeling: INR habitat models (2005 vs. 2019) depict patchy but broad predicted distributions across western and central Oregon, based on estimated occupancy in 12-digit HUC watersheds intersected with statewide wildlife habitat maps and a habitat suitability matrix (INR 2005, 2019).

Confidence: *Moderate*. INR models provide broad, unvalidated representations of predicted habitat consistent with occurrence records, but no recent Oregon-specific modeling or validation exists. Broad range is well documented, but contact zones with *A. montanus* in central Oregon need clarification.
Gaps: No recent Oregon-specific modeling or genetic analysis.

Distribution Summary

Across taxa, distributional patterns highlight a gradient of range sizes and ecological specializations. *Dicamptodon tenebrosus* and *Ascaphus truei* are the most broadly distributed, spanning multiple ecoregions and elevational zones. *Dicamptodon copei* is narrowly confined to steep-gradient headwaters in disjunct Coast and Cascade populations, while torrent salamanders (*Rhyacotriton kezeri* and *R. variegatus*) are highly endemic and patchily distributed. Broad patterns are well documented at county and ecoregional scales, but watershed-scale resolution is limited, especially in contact zones (*A. truei* vs. *A. montanus*, *R. variegatus* vs. *R. cascadae*) and at distributional edges. Fine-scale elevational and hydrologic limits remain poorly quantified. *R. kezeri* is an exception, with Thurman et al. (2025) providing new rangewide occupancy estimates and habitat-suitability models, but comparable updates are lacking for the other taxa.

Population Diversity and Connectivity

Understanding patterns of population diversity and connectivity across headwater amphibians is critical for assessing long-term viability, especially in landscapes fragmented by forest management. The AMPC questions emphasize whether populations are isolated at watershed scales, whether there are identifiable barriers or corridors, and how these patterns affect resilience. Measures of population diversity may include genetic variation, demographic structure, and ecological distinctness, all of which inform the capacity for dispersal and persistence under changing environmental conditions.

Cope's Giant Salamander (*Dicamptodon copei*)

Population Diversity: Available data for *D. copei* remain limited and geographically restricted. Published molecular work includes only a few Oregon sites, primarily Still Creek and the Boulder/White River basin, with most sampling occurring in Washington, leaving the majority of Oregon unsampled. Populations in Oregon are disjunct between the Coast and Cascade Ranges, with no confirmed linkage. Although Oregon-specific data are scarce, studies of the congener *D. tenebrosus* indicate high genetic structure at small spatial scales, suggesting that *D. copei* likely exhibits similarly low gene flow and strong population differentiation between basins, particularly given its patchy distribution and hydrologic constraints (Good & Wake 1992). Molecular analyses by Steele et al. (2005, 2007, 2009) and Spear et al. (2011) identified at least four well-supported lineages corresponding to major watersheds and confirmed the Columbia River as a significant barrier to gene flow. These findings, based largely on Washington populations, are further supported by landscape-genetic modeling showing that stream networks act as primary corridors, while drying, culverts, and fragmentation impede dispersal (Trumbo et al. 2013). Recent fieldwork documented isolated *D. copei* populations east of the Cascade Crest in the White River basin, extending the known range and confirming disjunct occurrences in Oregon that support earlier hypotheses of strong watershed isolation (Bury et al. 2017). Collectively, these studies highlight strong regional structure but remain based on a small number of Oregon samples, which are insufficient to evaluate population diversity or connectivity at watershed scales.

Connectivity: Occupancy tied to steep-gradient headwaters limits natural dispersal between watersheds, and neoteny in cold streams further restricts dispersal potential across dry terrain (Adams & Bury 2002). Roads and forest fragmentation are likely to exacerbate isolation, but empirical data are lacking.

<u>Coastal Giant Salamander (*Dicamptodon tenebrosus*)</u>

Population Diversity: Range-wide studies demonstrate substantial differentiation across ecoregions (Good & Wake 1992; Auteri et al. 2022), with mitochondrial and nuclear markers identifying distinct coastal and interior lineages. Reach-scale analyses showed that variation in abundance and biomass was explained mainly by physical habitat variables (pool area and substrate size) rather than biotic factors, suggesting that local population density and persistence are driven by habitat structure rather than interspecific interactions (Neal et al. 2024). Earlier molecular and occupancy data (Daugherty et al. 1983; Spear et al. 2011) also indicated moderate genetic subdivision among basins and low dispersal between tributaries. Oregon populations occur near the center of this range and likely encompass contact zones between northern and southern clades, though Oregon-focused phylogeographic resolution remains limited in the materials reviewed here. Variation in life history, particularly facultative neoteny and tolerance for warmer, lower-gradient streams, suggests greater ecological plasticity and gene flow relative to *D. copei*.

Connectivity: Adults of *D. tenebrosus* are capable of terrestrial dispersal overland and across low divides, which likely facilitates connectivity across adjacent watersheds and forest mosaics (Nussbaum et al. 1983; Adams & Bury 2002). Genetic data elsewhere indicate moderate gene flow among subpopulations, but empirical measures of dispersal distance and effective population size remain lacking for Oregon.

<u>Columbia Torrent Salamander (*Rhyacotriton kezeri*)</u>

Population Diversity: *R. kezeri* exhibits strong local differentiation and limited gene flow typical of the genus. Phylogenetic analyses show *R. kezeri* as a distinct lineage within *Rhyacotriton* (Good & Wake 1992), with evidence of fine-scale isolation among sub-basins in the northern Coast Range. Populations are small, patchy, and restricted to perennial seeps and spring-fed headwaters. While no published molecular work has focused exclusively on Oregon populations, habitat and demographic studies (Steele et al. 2003; Russell et al. 2004) demonstrate strong site fidelity, small home ranges, and dependence on stable cold-water refugia, which are ecological correlates of low dispersal and high local differentiation.

Connectivity: Limited mobility and dependence on cold, saturated substrates result in isolation at sub-basin scales (Steele et al. 2003; Russell et al. 2004; Olson & Ares 2022). Recent occupancy modeling (Thurman et al. 2025) found detections in 72% of surveyed headwater reaches, with occupancy strongly linked to slope, summer water balance, and canopy cover, which are variables that also predict potential fragmentation. These data provide an ecological proxy for population diversity where genetic sampling is absent, highlighting priority areas for future genetic monitoring.

Southern Torrent Salamander (*Rhyacotriton variegatus*)

Population Diversity: *R. variegatus* exhibits pronounced population structure across its range, with both genetic and ecological differentiation among regions. Phylogenetic analyses identified three major clades (northern coastal, Oregon, and California) reflecting deep lineage separation shaped by historical river and climate barriers (Wagner 2000; Good & Wake 1992). Within Oregon, populations show distinctiveness north and south of the Willamette River, which functions as a strong genetic and ecological boundary (Wagner et al. 2006). Landscape-genetic analyses demonstrate reduced diversity and increased differentiation in fragmented northern populations, with forest canopy continuity emerging as the strongest predictor of gene flow (Emel & Storfer 2015; Emel et al. 2019). Despite these patterns, occupancy and demographic studies suggest some resilience under moderate management: salamanders persist in shaded, mid-aged forest stands where cold water, coarse substrates, and canopy cover are maintained (Kroll et al. 2008; Olson & Ares 2022). Collectively, these findings indicate that *R. variegatus* maintains high population diversity at regional scales but limited genetic exchange among basins, with local persistence dependent on microclimatic refugia.

Connectivity: Dispersal is largely confined to perennial headwater corridors with continuous canopy and saturated substrates. Field observations in the Oregon Coast Range found most *R. variegatus* within a few meters of water, with rare individuals detected up to ~160 m from permanent streams, indicating extremely limited terrestrial movement and strong association with saturated substrates (Leppin et al. 2020). Major rivers (e.g., Yaquina, Willamette, Smith) and upland forest gaps act as strong barriers, while road density and forest fragmentation further constrain connectivity (Emel et al. 2019). These factors, combined with slow life histories and high site fidelity, suggest that recolonization following disturbance is rare and that populations function as semi-isolated headwater demes within larger watersheds.

Coastal Tailed Frog (*Ascaphus truei*)

Population Diversity: Phylogeographic studies across the Pacific Northwest reveal deep divergence between coastal and interior lineages, corresponding to glacial refugia and long-term isolation across the Cascade crest (Nielson et al. 2001; Macey et al. 2001). Oregon populations belong primarily to the coastal lineage, though subtle morphological and mitochondrial variation among basins suggests limited local differentiation (Miller et al. 2006). No clear genetic breaks have been documented within Oregon, but ecological variability, including differences in elevation, temperature, and larval development timing, implies localized adaptation within the broader coastal clade. Demographically, populations are stable where perennial flow and riparian canopy remain intact but decline sharply in intermittent or disturbed systems (Hayes & Quinn 2015).

Connectivity: *A. truei* display strong site fidelity and extremely limited terrestrial dispersal; adults rarely cross ridgelines or move more than a few hundred meters from natal streams (Hayes et al. 2006). Population connectivity is maintained primarily through continuous stream networks, with hydrologic barriers and canopy loss sharply reducing exchange among tributaries. No Oregon-specific genetic discontinuities have been documented, but potential contact zones with *A. montanus* east of the Cascades warrant molecular verification. Continued monitoring of flow permanence and riparian integrity is likely to provide the best proxy for assessing connectivity and population stability.

Population Diversity and Connectivity Summary

Information on population diversity and connectivity is uneven among the focal species. Torrent salamanders have been studied more extensively than giant salamanders or tailed frogs, largely because of their narrow habitat ranges and limited dispersal. Across the genus *Rhyacotriton*, populations show strong structure, fine-scale isolation, and small, patchily distributed sub-basin populations. In contrast, *Dicamptodon* and *Ascaphus* occupy broader ranges, but Oregon-specific analyses of population diversity and gene flow remain limited.

Substantial data gaps persist across all taxa. No population-genomic studies have quantified effective population size, genetic diversity, or inbreeding risk. Empirical measures of connectivity, such as corridor use, dispersal distances, or demographic exchange among watersheds are scarce, and most inferences rely on habitat correlates or occupancy models rather than direct genetic evidence. For *Dicamptodon*, connectivity between Oregon Coast and Cascade populations has not been evaluated, and for *Ascaphus*, population-level data within Oregon are minimal, including a lack of genetic verification in potential contact zones with *A. montanus*. *Rhyacotriton kezeri* provides a partial exception: recent rangewide habitat-suitability and occupancy modeling (Thurman et al. 2025) identified slope, summer water balance, and canopy cover as strong predictors of occurrence, offering an emerging framework for assessing watershed-scale connectivity even where genetic data remain limited.

Local Habitat Factors

Local habitat drivers are key to understanding occupancy and persistence of headwater amphibians. The AMPC emphasized the need to identify microhabitat variables which, in part, determine distribution (e.g., stream order, gradient, substrate, canopy cover, hydrology, geology, and temperature), and to assess how these factors vary at watershed scales. Summaries below integrate results from the INR Sensitive Species Accounts and supporting literature.

Cope's Giant Salamander (*Dicamptodon copei*)

Stream Characteristics: Restricted to 1st–3rd order perennial headwater streams, typically cold, high gradient, and shaded by closed canopy coniferous forests (Adams & Bury 2002; Roni 2002; Foster & Olson 2014). Channels generally exhibit riffle–pool morphology with coarse substrates, abundant cobbles, woody debris, and undercut banks that provide cover and foraging habitat. Neoteny, the retention of larval traits into reproductive adulthood, is common in colder or high elevation streams, allowing populations to persist in permanently aquatic environments but further limiting dispersal among isolated drainages. Both larvae and adults are most abundant in steep gradient reaches with stable baseflows and minimal fine sediment deposition (Foster & Olson 2014).

Microhabitat Associations: Most abundant in streams with riffle–pool morphology, cobbles, and woody debris. Adults and larvae occupy undercut banks, plunge pools, and interstitial spaces in gravel and cobble substrates. Field syntheses report preferred stream temperatures of ~3–14 °C, with physiological stress near ≥21 °C, and animals are most often encountered in pool sections of streams <1–2 m wide (Adams & Bury 2002; Roni 2002; Foster & Olson 2014).

Riparian Forest Context: Strongly tied to closed-canopy coniferous forests. Occupancy probability declines in managed stands with reduced canopy cover and stream shading (Bury et al. 1991). Abundance increases with higher levels of coarse woody debris (Bisson et al. 2002; Steele et al. 2002).

Coastal Giant Salamander (*Dicamptodon tenebrosus*)

Stream Characteristics: Uses a broader range of aquatic habitats than *D. copei*, including small streams, seeps, ponds, and lakes, as well as riparian zones of larger streams in coniferous forests (Bury et al. 1991; Olson & Weaver 2007). It is not restricted to steep gradient headwaters and can persist in lower gradient channels. Larvae occupy pools and runs with coarse substrates, while adults are often terrestrial and may shelter under logs, bark, or moist soil near aquatic habitats (Bury et al. 1991; Olson & Weaver 2007).

Microhabitat Associations: Occupies both steep-gradient and low-gradient streams. Larvae are more tolerant of variable substrates and flow regimes compared to *D. copei*. Recent sampling across 24 fish-bearing headwater streams in the northern Oregon Coast Range documented consistent occupancy of *D. tenebrosus* in second-growth forests (30–50 yr riparian age) with co-occurring trout and sculpin (Neal et al. 2024). Abundance and biomass were best predicted by pool area and substrate size, with higher densities in reaches containing smaller pools and finer substrates, while canopy cover, wood volume, and fish densities were not significant predictors (Neal et al. 2024). These findings underscore tolerance of managed forest conditions where cold, coarse-substrate headwaters remain intact.

Riparian Forest Context: Adults frequently terrestrial, sheltering under logs, bark, or moist soil near aquatic habitats. More tolerant of managed forests, but still dependent on moist, shaded riparian conditions.

Columbia Torrent Salamander (*Rhyacotriton kezeri*)

Stream Characteristics: Restricted to cold, perennial headwater streams, seeps, and splash zones (Steele et al. 2003; Russell et al. 2004). Often associated with steep gradients, coarse substrates, and basalt geology in shaded montane basins. Populations show strong site fidelity and patchy distributions linked to specific geologic substrates and cooler aspects, reflecting limited dispersal and sensitivity to drying or canopy loss (Wilkins & Peterson 2000; Steele et al. 2003; Russell et al. 2004).

Microhabitat Associations: Strongly tied to seep habitats and high water permanence; occupancy declines in intermittent streams. Sheridan & Olson (2013) found torrent salamanders to be dominant assemblage members in zero-order basins, underscoring reliance on very small, spring-fed channels. Rangewide habitat-suitability modeling (Thurman et al. 2025) identified slope, summer water balance, streamflow permanence, and canopy cover as the strongest predictors of occurrence, with highest suitability where baseflows were stable and riparian shading remained intact. Thermal associations indicate presence mainly in streams ≤ 12 °C (Russell et al. 2004). Occupancy has been shown to be lowest in recent (< 5 yr) clearcuts and highest in mid-aged (35–60 yr) stands (Bury & Corn 1988; Kroll et al. 2008), suggesting a non-linear response to forest age. Occupancy is greatest in perennial seep and spring habitats within mature or mid-aged forest stands and lowest in recently harvested or intermittent channels (Bury & Corn 1988; Grialou et al. 2000; Olson & Ares 2022).

Riparian Forest Context: Highly sensitive to canopy loss, which alters temperature and hydrology (Olson & Ares 2022). Populations are patchily distributed and tied to intact forest cover, though geology and elevation are often stronger predictors of occurrence than forest age (Russell et al. 2004; Olson & Ares 2022).

<u>Southern Torrent Salamander (*Rhyacotriton variegatus*)</u>

Stream Characteristics: A headwater obligate inhabiting small-order, cold, perennial streams, seeps, springs, and splash zones with coarse substrates and high canopy closure, often exceeding 80 percent (Welsh & Lind 1996; Olson & Ares 2022). Occupancy is strongly tied to cold, well-oxygenated flows and declines sharply with canopy loss, sedimentation, or seasonal drying. Populations occur across the Coast Range, Klamath Mountains, and West Cascades, including disjunct high-elevation sites near the range of *Rhyacotriton cascadae* without evidence of hybridization (Good & Wake 1992; Wagner et al. 2006).
Microhabitat Associations: Strong association with cold, well-oxygenated flows. Sheridan & Olson (2013) found torrent salamanders to be prevalent in zero-order basins, indicating the importance of spring-fed headwaters and seep habitats.
Riparian Forest Context: Highly sensitive to drying and canopy reduction. In the central Cascades, disjunct populations occur at higher elevations in steep-gradient streams (Wagner et al. 2006). Temperature studies indicate optimal abundances at 8–13 °C, with stress near ~17.2 °C and critical maxima around 25–29 °C, confirming strong cold-water dependence (Welsh & Lind 1996; Bury 2008). Like *R. kezeri*, occupancy peaks in mid-aged stands (35–60 yrs.) and declines in recent clear cuts, but the species is not strictly old-growth dependent (Wilkins & Peterson 2000; Kroll et al. 2008;).

<u>Coastal Tailed Frog (*Ascaphus truei*)</u>

Stream Characteristics: Primarily associated with cold, fast-flowing, shaded perennial headwater streams, often described as a headwater obligate species, meaning it breeds and develops almost exclusively within these small, perennial channels (Hayes et al. 2006; Hayes & Quinn 2015). Adults use riffles, pools, and waterfalls, while larvae cling to cobbles and bedrock in high-gradient channels. Populations are most often found in catchments larger than 50 hectares and in streams at least one meter wide with coarse substrates of gravel and cobble 55–125 mm in diameter (Hayes et al. 2006; Kroll et al. 2010). Occupancy is patchy across basins, with limited dispersal across

ridgelines (Hayes et al. 2006). Detections are more frequent in older forests greater than 100 years but also occur in younger managed stands where riparian canopy and substrate integrity remain intact (Stoddard & Hayes 2005; Kroll et al. 2008).
Microhabitat Associations: Larvae rely on coarse gravel and cobble substrates (55–125 mm), with avoidance of fine sediments (Adams 1993; Karraker 2006). Populations are associated with catchments >50 ha (Hayes et al. 2006; Kroll et al. 2010). Thermal tolerances include oviposition near ~11.2 °C (Adams 1993), larval optima near ~12 °C, and upper thresholds near ~18 °C (Karraker 2006; Twitchell 2013).

Riparian Forest Context: Detections are more frequent in older forests (>105 years) but also occur in younger managed stands where riparian canopy and instream substrates remain intact (Stoddard & Hayes 2005; Kroll et al. 2008).

Local Habitat Factors Summary

All species are associated with cold, perennial flows, coarse substrates, and shaded riparian conditions, but their tolerances and flexibility differ. Torrent salamanders are the most microhabitat-restricted, confined to seeps, splash zones, and zero-order basins with narrow thermal ranges. *D. copei* is limited to steep-gradient headwaters, while *D. tenebrosus* can use larger streams and terrestrial forest habitats. *A. truei* is tightly tied to high-gradient cobble and bedrock channels but can persist in younger stands when instream conditions remain intact. The knowledge base is limited by a lack of quantitative thresholds for slope, canopy, and flow permanence across most species. Thermal tolerance data exist but are scattered across a handful of lab and field studies, with few replicated experiments. Seasonality, terrestrial dispersal, and responses to disturbance remain poorly studied. *R. kezeri* is again a partial outlier: Thurman et al. (2025) quantified slope, canopy cover, and hydrologic predictors of occupancy at watershed and reach scales, providing thresholds that reinforce earlier qualitative observations. For the other taxa, habitat–land use interactions are documented only inconsistently and largely from single-region studies.

Torrent Salamander Population Status and Trends

Understanding population status and trends for torrent salamanders is central to evaluating persistence under the Forest Practices Act. Both *Rhyacotriton kezeri* and *R. variegatus* are narrowly distributed, headwater-dependent salamanders that rely on perennial, cold, shaded flow regimes. Their patchy distributions and low dispersal capacity make them especially sensitive to canopy removal, hydrologic alteration, and drought. Long-term demographic data are lacking, but multiple studies now provide complementary insight into occupancy, abundance, and persistence across gradients of forest age and disturbance.

Columbia Torrent Salamander (*Rhyacotriton kezeri*)

Population Status: Earlier field studies reported presence in roughly half of first- and second-order perennial streams surveyed in the northern Oregon Coast Range, with reported densities ranging from 0–4.8 individuals per linear meter of stream and mean densities of approximately 0.47 individuals/m², depending on sampling scale (Wilkins & Peterson 2000; Russell et al. 2004).

Rangewide habitat-suitability modeling (Thurman et al. 2025) identified slope, summer water balance, streamflow permanence, and canopy cover as the strongest predictors of occurrence, with highest suitability in basins maintaining stable baseflows and intact riparian shading. These models provide the first quantitative framework for assessing relative occupancy probabilities, though standardized abundance estimates remain unavailable.

Trends and Pressures: Historical modeling estimated roughly a 66% reduction in suitable habitat since Euro-American settlement, primarily due to canopy loss and riparian fragmentation (Kagan et al. 1999). Subsequent INR updates (2005, 2019) depict continued contraction, although recent analyses suggest small, perennial headwater refugia remain common within the range (Olson & Ares 2022). There are no formal long-term abundance series, but repeated site assessments indicate strong site fidelity and limited recolonization following disturbance (Steele et al. 2003). *R. kezeri* remains common where canopy and hydrology are intact, yet absence from clearcuts and intermittently flowing reaches indicates continued vulnerability to drying and harvest (Bury & Corn 1988; Olson & Ares 2022).

Distribution on FPA Lands: The majority of modeled suitable habitat for *R. kezeri* occurs in the northern Oregon Coast Range, where roughly 60 percent of the landscape is privately owned and managed under FPA rules (Kagan et al. 1999; Olson & Ares 2022).

Southern Torrent Salamander (*Rhyacotriton variegatus*)

Population Status: *R. variegatus* occurs throughout the Coast Range and Klamath Mountains, with occupancy rates between 40–70% in suitable perennial headwaters (Welsh & Lind 1996; Olson & Ares 2022). Larval densities of 0–12.9 individuals/m^2 have been reported (Nussbaum & Tait 1977), with adults concentrated in shaded riffles, seeps, and splash zones. Genetic studies indicate pronounced population structure and reduced heterozygosity in fragmented northern Oregon populations, consistent with restricted dispersal and isolation by distance (Emel & Storfer 2015; Emel et al. 2019).

Trends and Pressures: Landscape-scale modeling indicates approximately 55% loss of suitable habitat since settlement, with the greatest reductions in the Coast Range and Klamath Mountains (Kagan et al. 1999). Hydrologic permanence and canopy continuity are key determinants of occupancy, and populations are rarely detected in intermittent or high-temperature streams (>17 °C; Welsh & Lind 1996; Bury 2008). Although quantitative trend data are limited, local studies show persistence in buffered or mid-aged stands and sharp declines in recently harvested reaches (Corn & Bury 1989; Kroll et al. 2008). Fragmentation limits recolonization after harvest, although recovery may occur in 30–60-year stands where riparian canopy exceeds 70% (Olson & Ares 2022). Climate-change modeling and recent observations suggest increasing drought and reduced stream permanence will further constrain habitat connectivity (Emel 2015; Olson & Ares 2022).

Distribution on FPA Lands: *R. variegatus* spans the Coast Range and Klamath Mountains, encompassing large blocks of private industrial timberland in Douglas, Coos, and Curry Counties (Kagan et al. 1999; Olson & Ares 2022).

Torrent Salamander Trends Summary

Available evidence suggests that torrent salamander populations remain widespread in forested headwater refugia but have likely declined relative to historical distributions. Both species exhibit narrow habitat tolerances, strong site fidelity, and limited recolonization capacity, which constrain recovery following disturbance (Bury & Corn 1988; Russell et al. 2004; Olson & Ares 2022). Although quantitative, rangewide trend data are lacking, multiple indicators including historic habitat loss (Kagan et al. 1999), high genetic differentiation and isolation among basins (Emel & Storfer 2015; Emel et al. 2019), and absence from recently harvested or intermittent streams point to reduced connectivity and localized declines rather than broad recovery. For *R. kezeri*, new rangewide habitat-suitability modeling (Thurman et al. 2025) provides a baseline for evaluating occupancy probability and environmental thresholds, while assessments of *R. variegatus* continue to rely on regional studies from the past two decades (Welsh & Lind 1996; Kroll et al. 2008; Olson & Ares 2022). These studies describe associations with forest age and hydrology but were not designed to isolate causal drivers of decline.

Overall, current research offers a baseline understanding of distribution and persistence patterns but not quantitative population trends. No time-series data exist to estimate statewide or watershed-scale trajectories, extinction, or recolonization rates. Responses to compounding stressors (e.g., drought, canopy alteration, and flow intermittency) remain poorly characterized. Coordinated, probabilistic sampling across ownerships, coupled with temperature and flow monitoring, would provide the long-term foundation needed to evaluate torrent salamander trends under the Forest Practices Act.

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