

## Introduction

For this literature 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; 5) baseline conditions that can inform monitoring design, and 6) how riparian management areas, Type N streams, and unstable slope protections affect habitat for Columbia and Southern Torrent Salamanders. Given the AMPC's framing, our review focuses on synthesizing available evidence in these topical areas, rather than comprehensively summarizing all amphibian ecology literature.

The review addresses five species of concern: 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*). 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. Because no INR Sensitive Species account exists for the Coastal Giant Salamander, we consulted the existing literature for this species.

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 management-relevant gaps, and designing monitoring under the Forest Practices Act. The AMPC emphasized the need to characterize distribution at watershed scales (e.g., HUC-10 or finer), document elevational and ecoregional patterns, and evaluate the confidence of existing data

Cope's Giant Salamander (*Dicamptodon copei*)

**Range and Counties:** Restricted to two disjunct regions: (1) 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).

**Watershed Patterns:** Occupies 1st–3rd order, cool, perennial headwater streams with coarse substrates, riffle–pool morphology, and closed-canopy coniferous forests (Adams & Bury 2002; Roni 2002). Neoteny is common in colder or high-elevation streams. Larvae and adults are

most abundant in steep-gradient streams with abundant cobbles, woody debris, and undercut banks (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).

#### 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).

**Watershed Patterns:** Occupies small streams, seeps, ponds, and lakes in coniferous forests, as well as riparian zones of larger streams. Unlike *D. copei*, it is not restricted to steep-gradient headwaters and can persist in lower-gradient streams. Adults are more terrestrial and may occupy moist forest floors near aquatic habitats (Bury et al. 1991; Olson & Weaver 2007).

**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). **Watershed-scale change estimates are 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; Bullock 2023). 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).

**Watershed Patterns:** A headwater obligate in cold, perennial streams, seeps, and splash zones. Frequently associated with steep gradients, coarse substrates, and patchy basin distributions, with strong site fidelity. Populations are often linked to specific geologic substrates and cooler, shaded aspects (Wilkins & Peterson 2000; 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  $\approx 12$  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).

### Southern Torrent Salamander (*Rhyacotriton variegatus*)

**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).

**Watershed Patterns:** A headwater obligate inhabiting small-order streams, seeps, springs, and splash zones with coarse substrates and high canopy closure (>80%). Occupancy is strongly tied to cold, well-oxygenated flows and declines with canopy loss or drying (Welsh & Lind 1996; Olson & Ares 2022). In the central Cascades, disjunct populations occur at higher elevations near the range of *R. cascadae* without evidence of hybridization (Good & Wake 1992; Wagner et al. 2006).

**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).

### Coastal Tailed Frog (*Ascaphus truei*)

**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 metamorph detections more frequent at higher elevations (Hayes & Quinn 2015; WA Herp Atlas 2017).

**Watershed Patterns:** A headwater obligate breeding in cold, fast-flowing, shaded perennial streams with riffles, pools, and waterfalls. Larvae cling to coarse cobbles and bedrock in high-gradient channels (Hayes et al. 2006; Hayes & Quinn 2015). Populations are associated with catchments >50 ha and perennial channels ≥1 m wide with coarse substrates, particularly gravels and cobbles 55–125 mm (Hayes et al. 2006; Kroll et al. 2010). Occupancy is patchy across basins, with limited dispersal across ridgelines (Hayes et al. 2006). Detections are positively associated with older forests (>105 years) but can also occur in younger managed stands where riparian canopy and substrates remain intact (Stoddard & Hayes 2005; Kroll et al. 2008).

**Modeling:** INR habitat models (2005 historic vs. 2019 current) 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).

### Distribution Summary

Across taxa, distributional patterns highlight a gradient of range size and ecological specialization. *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.

### Genetics and Connectivity

Understanding genetic diversity and connectivity across populations of 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. For the focal species, available data are uneven: torrent salamanders have received more attention due to their narrow ranges, while giant salamanders and tailed frogs have broader distributions but limited genetic study in Oregon.

#### Cope's Giant Salamander (*Dicamptodon copei*)

**Genetic Structure:** Genetic studies are sparse. Populations in Oregon are disjunct (Coast vs. Cascade ranges) with no confirmed genetic linkage. By analogy to *D. tenebrosus*, which shows high local structure (Good & Wake 1992), *D. copei* may also exhibit restricted connectivity between basins.

**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.

#### Coastal Giant Salamander (*Dicamptodon tenebrosus*)

**Genetic Structure:** Range-wide genetic work has shown substantial differentiation across major ecoregions (Good & Wake 1992). No Oregon-specific phylogeographic study has been published.

**Connectivity:** More ecologically flexible than *D. copei*, adults are capable of terrestrial dispersal and likely maintain greater connectivity across low divides and riparian corridors, though quantitative measures are lacking for Oregon.

#### Columbia Torrent Salamander (*Rhyacotriton kezeri*)

**Genetic Structure:** Torrent salamanders are characterized by strong population structure and restricted dispersal. Phylogenetic studies show deep lineage divergence across the genus, with *R. kezeri* distinct but internally structured (Steele et al. 2005, 2007, 2009). Populations are patchily distributed and often isolated in headwater networks.

**Connectivity:** Strong fidelity to seep habitats and low dispersal ability suggest isolation at the sub-basin scale (Steele et al. 2003; Russell et al. 2004). Fragmentation of forest cover and hydrologic changes further exacerbate isolation (Olson & Ares 2022). Recent rangewide occupancy surveys and boosted regression tree modeling reinforce these conclusions: *R. kezeri* was detected at 72% of surveyed sites, with counts positively correlated with modeled suitability. Key predictors included slope, summer water balance, streamflow permanence, and canopy cover. These products (HUC12 and 30 m reach-level) identify potential refugia and fragmented watersheds, providing a framework for prioritizing genetic monitoring and conservation (Thurman et al. 2025).

#### Southern Torrent Salamander (*Rhyacotriton variegatus*)

**Genetic Structure:** Genetic work indicates pronounced differentiation between northern (Oregon) and southern (California) populations, with potential sub-structuring within Oregon (Good & Wake 1992; Emel & Storfer 2015).

**Connectivity:** Strong association with cold perennial flows and closed-canopy forests suggests dispersal is limited to connected headwater systems. In the central Cascades, populations abut *R. cascadae* without evidence of hybridization, indicating reproductive isolation even in close proximity (Wagner et al. 2006).

#### Coastal Tailed Frog (*Ascaphus truei*)

**Genetic Structure:** Range-wide analyses (Nielson et al. 2001; Macey et al. 2001) identified major clades corresponding to coastal vs. interior populations, but Oregon populations are generally part of the coastal lineage. Limited work has examined within-Oregon structure.

**Connectivity:** Adults show strong site fidelity and limited overland dispersal across ridgelines (Hayes et al. 2006). Population connectivity likely occurs primarily along stream networks, with dispersal constrained by watershed divides. No Oregon-specific genetic barriers have been documented, but contact with *A. montanus* east of the Cascades suggests a zone where genetic verification is needed.

#### Genetics and Connectivity Summary

Genetic and connectivity data are uneven across taxa. Torrent salamanders show consistently strong structure and low dispersal, with patchy sub-basin populations. In contrast, giant salamanders and tailed frogs have broader ranges but remain under-studied genetically in Oregon. **Key gaps include the absence of population genomic studies that assess genetic diversity, effective population size, or inbreeding risk; little empirical data on connectivity corridors or barriers at watershed scales; and no genetic verification in contact zones (*A. truei* vs. *A. montanus*). For *Dicamptodon*, there is no published work quantifying connectivity between Oregon Coast and Cascade populations, and for *Ascaphus*, Oregon-specific genetic studies are virtually absent. *R. kezeri* again represents a partial exception, as Thurman et al. (2025) provides a robust framework for linking occupancy and landscape connectivity, though direct genetic data remain sparse.**

## 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 (e.g., stream order, gradient, substrate, canopy cover, hydrology, geology, temperature) that determine distribution and to assess how these vary at watershed scales. Below we summarize habitat associations for each focal species.

### Cope's Giant Salamander (*Dicamptodon copei*)

**Stream Characteristics:** Restricted to 1st–3rd order perennial headwater streams, typically cold and high-gradient with coarse substrates (Adams & Bury 2002; 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 habitats than *D. copei*, including small streams, ponds, lakes, and seeps, as well as riparian zones of larger streams (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*.

**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 basalt geology and high-gradient channels.

**Microhabitat Associations:** Strongly tied to seep habitats and high-water permanence. Occupancy declines in intermittent streams. Sheridan & Olson (2013) found torrent salamanders as a dominant assemblage component in zero-order basins, underscoring reliance on very small, spring-fed channels. Recent range wide surveys detected *R. kezeri* at 72% of sites, with mean abundance ~12 individuals per person-hour, and boosted

regression tree models confirmed slope, summer water balance, streamflow permanence, and canopy cover as the strongest predictors of occupancy, with highest suitability where baseflows were stable and riparian canopy remained intact (Thurman et al. 2025). Thermal associations indicate presence mainly in streams  $\leq 12$  °C (Russell et al. 2004), and occupancy has been shown to be absent from 2–5-year clear cuts (Bury & Corn 1988), but highest in mid-aged (35–60 yrs.) stands (Kroll et al. 2008), suggesting stand age effects are non-linear. **Riparian Forest Context:** Sensitive to canopy loss, which alters temperature and hydrology (Olson & Ares 2022). Populations are patchily distributed and tied to intact forest cover. **Geology and elevation are often stronger predictors of occurrence than forest age** (Russell et al. 2004; Olson & Ares 2022).

#### Southern Torrent Salamander (*Rhyacotriton variegatus*)

**Stream Characteristics:** Occupies small-order streams, seeps, springs, and splash zones with coarse substrates and consistently high canopy closure (>80%) (Welsh & Lind 1996; Olson & Ares 2022). Research syntheses emphasize occupancy on the surface of large cobbles and in moist splash zones of cold waters (Welsh & Lind 1996; Bury 2008).

**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;).

#### Coastal Tailed Frog (*Ascaphus truei*)

**Stream Characteristics:** Occupies cold, fast-flowing, shaded perennial headwater streams with coarse substrates (Hayes et al. 2006; Hayes & Quinn 2015). Adults use riffles, pools, and waterfalls, while larvae cling to cobbles and bedrock in high-gradient channels. Streams are typically  $\geq 1$  m wide (Adams 1993; Karraker 2006).

**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

Columbia Torrent Salamander (*Rhyacotriton kezeri*)

Southern Torrent Salamander (*Rhyacotriton variegatus*)

## Monitoring Torrent Salamanders Across Landowner Types

Columbia Torrent Salamander (*Rhyacotriton kezeri*)

Southern Torrent Salamander (*Rhyacotriton variegatus*)

## Effects of Forest Practice Rules on Torrent Salamander Habitat

Columbia Torrent Salamander (*Rhyacotriton kezeri*)

Southern Torrent Salamander (*Rhyacotriton variegatus*)