WILDLIFE
IN MANAGED FORESTS

Forest Amphibians

Wildlife in Managed Forests – Project Overview

This publication is part of a series from the Oregon Forest Resources Institute (OFRI) that aims to synthesize current forest wildlife research findings and make that information available to foresters, wildlife managers and interested forest landowners, as well as other natural resource stakeholders. As part of OFRI's *Wildlife in Managed Forests* program, information is disseminated through publications such as this one, plus educational webinars, tours and conferences. Management recommendations provided in this publication are voluntary, and are not suggestions for policy.

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971-673-2944
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This publication is an update to the 2009 Wildlife in Managed Forests Stream Associated Amphibians *publication.*

PREPARED FOR THE OREGON FOREST RESOURCES INSTITUTE BY:

Fran Cafferata Coe, Certified Wildlife Biologist®, Cafferata Consulting
Tiffany Garcia, Ph.D., professor, Department of Fisheries and Wildlife, Oregon State University
Deanna Olson, Ph.D., research ecologist, U. S. Department of Agriculture, Forest Service
Julie Woodward, senior manager of forestry education, Oregon Forest Resources Institute

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1.0 Introduction

Amphibians play an important and distinctive role in forest ecosystems (Pilliod and Wind, 2008). They occur across forested watersheds in aquatic and upland habitats. Being on Earth the longest of any terrestrial vertebrates, they have been resilient through a vast array of changes over the millennia, and are known to occur on all continents except Antarctica. In particular, the United States is the world biodiversity hotspot for forest salamanders, and there are many unique species in the Pacific Northwest. Amphibians (especially the stream-associated ones) evolved to utilize one of the most consistent microclimates in the world. Amphibians are centrally positioned in food webs as both key predators and prey, and function to move energy between aquatic and terrestrial ecosystems. Amphibians also serve as environmental indicators.

Harvesting trees, building roads and other contemporary forest management activities cause disturbances to the landscape that can affect amphibian habitats. The magnitude of these effects is context-specific, and the long-term cumulative effects require further study and analysis. There are many factors to consider: the geology and forest type of a given area; latitude and elevation; slope steepness and aspect; proximity to water; stream temperature; and relative humidity. These all influence how – and to what extent – the varying types of forest management affect amphibian habitat.

Recent science is adding more depth and detail to the body of knowledge about amphibian responses to forest management. Scientists are learning more about the importance of smaller habitat features such as substrate (gravel, cobble, boulders and down wood); microclimate; relationships with predators, prey and competitors in streams; patterns of movement within, across and along stream channels and over land; and resilience to disturbances.

The accruing knowledge is painting a more detailed picture of amphibian response to forest management, and is contributing to new best management practices for forestry that integrate aquatic and upland areas. As the picture becomes clearer, research findings provide forest managers with methodologies and strategies that will help protect amphibian habitat and biodiversity on forested lands.

Scientists are learning more about the importance of smaller habitat features such the down wood shown here.

2.0 Amphibians in Oregon forests

More than 30 amphibian species can be found in Oregon forests, occurring across wet and dry forested ecoregions (Figure 1). Oregon amphibians have highly variable life-history strategies. They can be short- or long-lived, produce small or huge numbers of young, disperse short or long distances, and occur in water and/or on land. Oregon amphibian habitats are often distinct, occurring in ephemeral ponds or perennial lakes and wetlands, small intermittent or larger perennial streams, moist riparian zones along aquatic areas, or upland forest microhabitats (Figure 2). Brief profiles of these species are presented below. A field guide will offer a full life-cycle description. Note that when describing the size of the amphibians we refer to the total length (tip to tail), which can sometimes be misleading if you find one that is missing part of its tail.

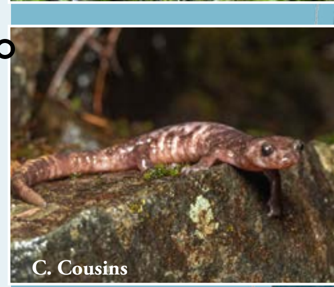
AMPHIBIAN SPECIES

Amphibian habitats are often distinct, such as the small waterfall shown here. They are found in ephemeral ponds or perennial lakes and wetlands, small intermittent or larger perennial streams, most riparian zones along aquatic areas or upland forest microhabitats.

Figure 1: Amphibians native to Oregon forests

Coast Range
- Columbia torrent salamander
- Southern torrent salamander
- Cope's giant salamander
- Coastal giant salamander
- Dunn's salamander
- Western red-backed salamander
- Del Norte salamander
- Clouded salamander
- California slender salamander
- Long-toed salamander
- Northwestern salamander
- Ensatina
- Rough-skinned newt
- Coastal tailed frog
- Western toad
- Pacific chorus frog
- Foothill yellow-legged frog
- Northern red-legged frog

Willamette Valley
- Coastal giant salamander
- Dunn's salamander
- Western red-backed salamander
- Oregon slender salamander
- Long-toed salamander
- Northwestern salamander
- Clouded salamander
- Ensatina
- Rough-skinned newt
- Western toad
- Pacific chorus frog
- Foothill yellow-legged frog
- Oregon spotted frog
- Northern red-legged frog



Klamath Mountains
- Southern torrent salamander
- Coastal giant salamander
- Dunn's salamander
- Del Norte salamander
- Siskiyou Mountains salamander
- Clouded salamander
- California slender salamander
- Long-toed salamander
- Northwestern salamander
- Ensatina
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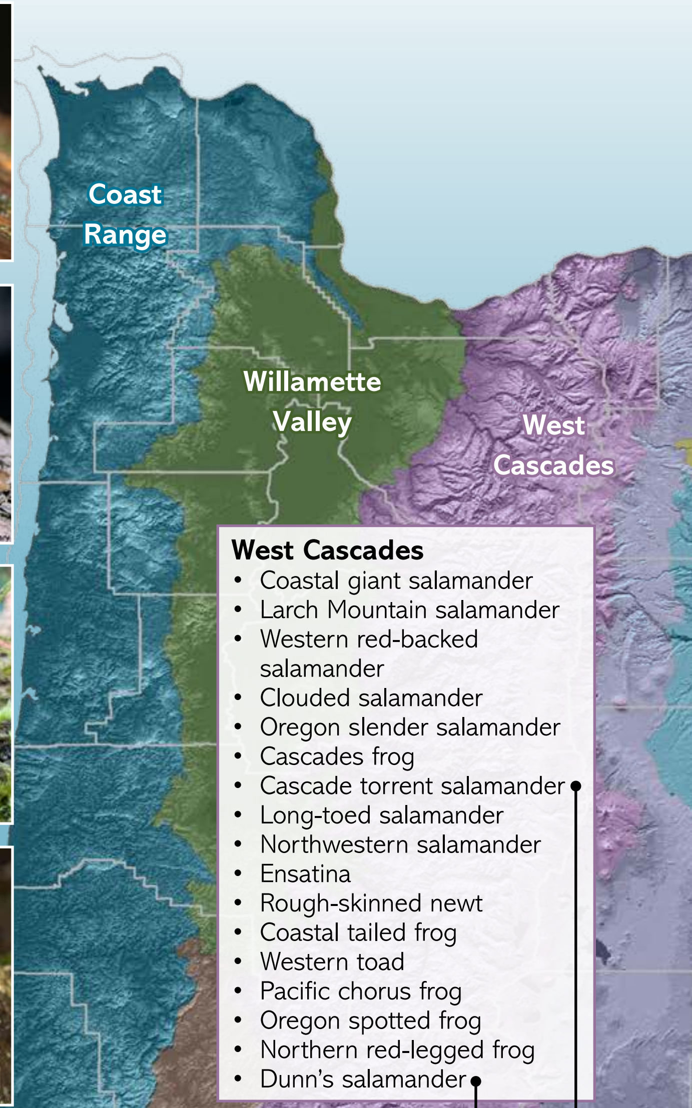
- Western toad
- Pacific chorus frog
- Foothill yellow-legged frog
- Northern red-legged frog
- Klamath black salamander



West Cascades
- Coastal giant salamander
- Larch Mountain salamander
- Western red-backed salamander
- Clouded salamander
- Oregon slender salamander
- Cascades frog
- Cascade torrent salamander
- Long-toed salamander
- Northwestern salamander
- Ensatina
- Rough-skinned newt
- Coastal tailed frog
- Western toad
- Pacific chorus frog
- Oregon spotted frog
- Northern red-legged frog
- Dunn's salamander

DISCLAIMER: This product is for informational purposes and may not be suitable for legal, engineering or surveying purposes. Please consult the original data sources to ascertain the usability of this product.

Data Sources: DEM from Oregon Geospatial Enterprise Office (GEO); ecoregions from USGS; county boundaries published in Oregon Revised Statutes (ORS 201.010 - 201.370).

Figure 2: Amphibian habitats of Oregon forests

Small streams

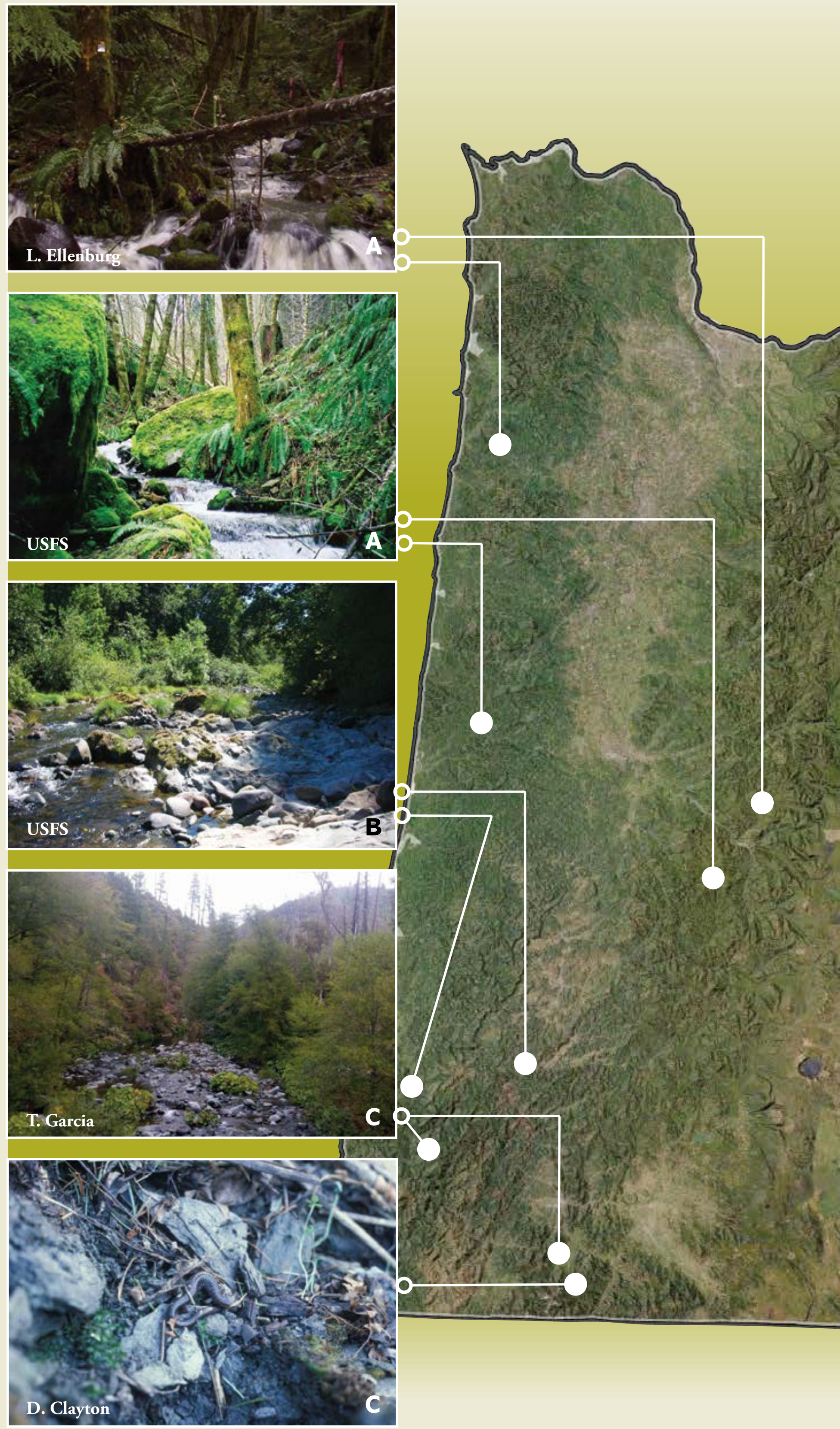
A. Small streams in forested headwaters provide cold water and substrates with interstitial refuge spaces for stream-breeding amphibians such as Pacific giant salamanders, torrent salamanders and tailed frogs. Torrent salamanders can occur in intermittent or ephemeral headwater streams, whereas giant salamanders and tailed frogs can use 1st- to 5th-order perennial streams. After metamorphosis, these species use stream banks, along with Dunn's, Western red-backed and Klamath black salamanders. Down wood and other habitat elements in forested uplands and ridgelines are used by these species along with ensatina, clouded salamanders, Oregon slender salamanders and pond-breeding amphibian species such as Northwestern salamanders and rough-skinned newts.

Large streams

B. In southwest Oregon, foothill yellow-legged frogs can be found in and along 1st- to 8th-order streams. They often breed in larger streams with cobble-to-boulder substrates and quiet stream-edge backwater areas, and use smaller streams for foraging, dispersal or overwintering.

Talus slopes

C. Talus slopes in the drier forests of southwest Oregon are key habitats for Del Norte and Siskiyou Mountains salamanders, where they are surface-active during cool moist seasons. Similarly, Larch Mountain salamanders occur on talus slopes in forests along the Columbia River Gorge to the north of Mount Hood. These terrestrial salamanders do not need pond or stream habitats, but rely on microsite conditions of forest substrates.



Background map data: Earthstar Geographics, Airbus, USGS, NGA, NASA, CGIAR, NCEAS, NLS, OS, NMA, Geodatastyrelsen, GSI and the GIS User Community.

Down wood

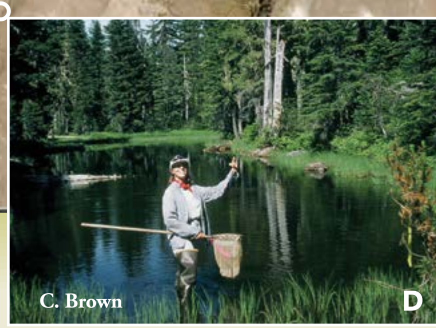
G. Some terrestrial-breeding salamanders rely on down wood for breeding sites, such as Oregon slender salamanders (shown here with eggs), ensatinas, clouded salamanders, and California and Oregon slender salamanders. Slender salamanders do not readily move long distances, and may require down wood or other cool, moist surface refugia in close proximity to disperse. Clouded salamanders are adept climbers and have been seen in red tree vole nests high in overstory canopy trees.

Perennial headwater streams

F. Cold, perennial headwater streams with coarse substrates in the dry forests of northeast Oregon are habitat for Rocky Mountain tailed frogs. After stream larvae undergo metamorphosis, moisture-dependent froglets and adults can rely heavily on cool, moist streamside areas.

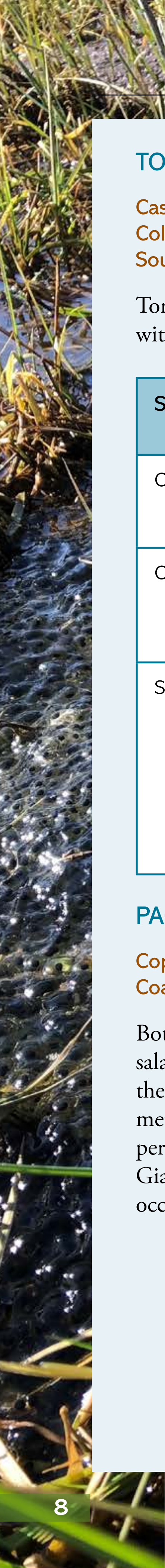
Eastern Oregon forests

E. Columbia spotted frogs breed in fens, inundated meadow ponds, beaver ponds, river backwaters and along some lakes within or near eastern Oregon forests. After metamorphosis, froglets and adults may have separate foraging and overwintering locations away from breeding sites, but they are usually found near water, and repeatedly return to the same breeding sites.



Cascade Range forests

D. Wet meadows, ponds and lakes in Cascade Range forests may serve as breeding habitat for Western toads, Cascades frogs, Oregon spotted frogs, Pacific chorus frogs, long-toed and Northwestern salamanders, and rough-skinned newts. Down wood, rocks and rodent burrows near such wetlands can be important refuge for metamorphs and adults, protecting them from thermal extremes or predators.



TORRENT SALAMANDERS

Cascade torrent salamander... *Rhyacotriton cascadae*
Columbia torrent salamander... *Rhyacotriton kezeri*
Southern torrent salamander... *Rhyacotriton variegatus*

Torrent salamanders occur in the montane forests of the Coast and Cascade ranges. They are small, with short snouts and large eyes. The larvae have small external gills they lose at metamorphosis.

Species	Size (inches)	Diet	Habitat	Range
Cascade	3 - 4.5	Mainly worms, snails and small arthropods such as insects, spiders and amphipods.	They are stream obligates and require small streams for breeding, rearing and foraging. Preferred habitat is within and near cold, clear streams flowing through moist coniferous forests. They can be the dominant vertebrate in intermittent streams, with a vertical migration into substrates during dry summer conditions. Often found under the gravel along the edges of a stream and in the spray zones of waterfalls. They disperse overland, over the ridgelines between adjacent forested watersheds, with upland associations to moist microhabitat conditions.	Western Cascade Range from central Ore. to southern Wash.
Columbia				Ore. Coast Range north of the Little Nestucca River and extending into southwestern Wash.
Southern				Calif. and Ore. Coast Range, north to the Little Nestucca River.

PACIFIC GIANT SALAMANDERS

Cope's giant salamander... *Dicamptodon copei*
Coastal giant salamander... *Dicamptodon tenebrosus*

Both of Oregon's giant salamander species are relatively large, but coastal giants are true giants of the salamander order and are top predators in the systems they inhabit. They are considered to be one of the largest terrestrial salamanders in the world. It can take several years for giant salamander larvae to metamorphose, and in some locations adults can retain aquatic forms (i.e., paedomorphosis), sometimes permanently. This is especially true for Cope's giants, the vast majority of which will never metamorphose. Giant salamanders and torrent salamanders occupy some of the same aquatic habitat, but torrents often occupy intermittent headwater streams while giants remain in larger streams with more permanent flows.

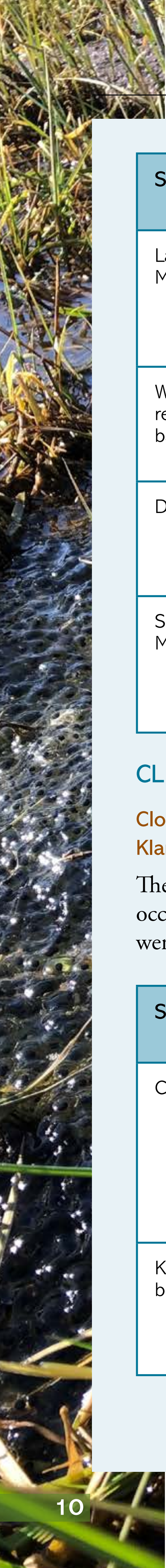
<table>
<tr><th>Species</th><th>Size (inches)</th><th>Diet</th><th>Habitat</th><th>Range</th></tr>
<tr><td>Cope’s</td><td>About 7.5</td><td rowspan="2">Fish, frogs, salamanders; a variety of aquatic and terrestrial invertebrates such as insects, snails and slugs, lizards, shrews, mice and even snakes. Aquatic salamanders take aquatic prey or whatever terrestrial prey enters the water.</td><td rowspan="2">Larval giants prefer cold, clear, fast-flowing streams in moist coniferous or mixed coniferous-deciduous forests. Streams are required for breeding and larval rearing. Cope’s giants typically remain in aquatic larval form throughout their lives, and are almost never seen as fully metamorphosed terrestrial adults. For coastal giants, after metamorphosis terrestrial adults can occur in riparian zones along streams, or they may disperse upland. They use subsurface microrefugia when in uplands, emerging during wet and humid conditions and dispersing across ridgelines of watersheds.</td><td>Northwest Ore. and southwest Wash., including the Olympic Peninsula, in and west of the Cascade Range.</td></tr>
<tr><td>Coastal</td><td>Up to about 14</td><td>Forests of both the Ore. Cascade and Coast ranges, with diminished distributions in the drier forests of southwestern Ore., western Wash. (excluding Olympic Peninsula), northwest Calif., extreme southwest British Columbia.</td></tr>
</table>

PLETHODON (LUNGLESS) SALAMANDERS

Dunn’s salamander .... ***Plethodon dunni***
Larch Mountain salamander .... ***Plethodon larselli***
Western red-backed salamander .... ***Plethodon vehiculum***
Del Norte salamander .... ***Plethodon elongatus***
Siskiyou Mountains salamander .... ***Plethodon stormi***

Plethodon species are part of a larger group of lungless salamanders in the family Plethodontidae, the woodland salamanders. They breathe through their skins. Unlike most other amphibians, they grow directly to adults without requiring an aquatic larval stage. The word “plethodon” means “many teeth,” and refers to the long row of teeth these salamanders have that enables them to break through the hard exoskeletons of prey species. In general, this group of salamanders prefers heavily forested, moist, shaded habitats with down wood and/or rock components present. Egg laying typically occurs in damp, decayed down wood or other temperature- and moisture-controlled crevices.

Species	Size (inches)	Diet	Habitat	Range
Dunn’s	4 - 6	Invertebrates such as beetles, worms and ants.	Common along stream banks, and may be found upslope in forested riparian zones.	West of the Cascade Range from southwestern Wash. to Calif.



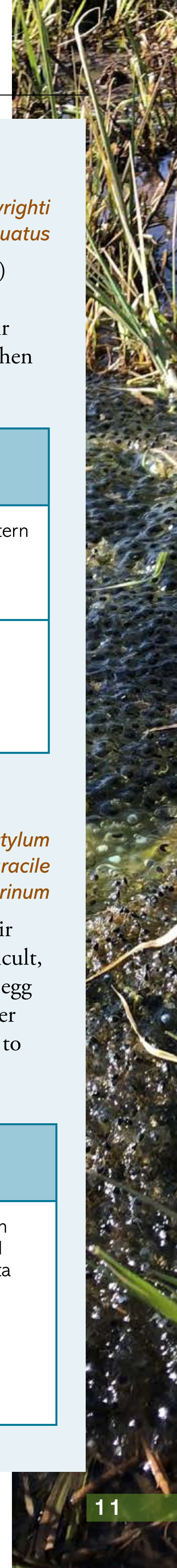
Species	Size (inches)	Diet	Habitat	Range
Larch Mountain	Up to 4	Invertebrates such as beetles, worms and ants.	Preferred habitat is shady, cool rock outcrops and talus slopes, although they are also found in moist coniferous and mixed forests.	Cascade Range and Columbia River Gorge of northern Ore. and southern Wash.
Western red-backed	Up to 4.5		Preferred habitat is in moist coniferous or mixed forests.	West of the Cascade Range from British Columbia to southern Ore.
Del Norte	Up to 6		Generally away from streams on north-facing slopes, or in areas with large conifers, rocks and down wood (Corkran 2006).	Coast Range and Siskiyou Mountains of southwestern Ore.
Siskiyou Mountains	Up to 5.5		Occur in close association to rocky slopes or outcrops, sometimes under wood debris, on forested north-facing slopes (Corkran 2006).	Highly restricted area of Siskiyou Mountains in southwestern Ore. and northwestern Calif.

CLIMBING SALAMANDERS

Clouded salamander........ *Aneides ferreus*
Klamath black salamander........ *Aneides klamathensis* (formerly the black salamander, *A. flavipunctatus*)

These salamanders can climb trees, and have been sighted in red tree vole nests in overstory trees and occasionally found in snags. Klamath black salamanders only recently gained full species status, as they were determined to be distinct from other populations of the black salamander.

Species	Size (inches)	Diet	Habitat	Range
Clouded	3 - 5	Climbing salamanders feed opportunistically on small arthropods such as mites, beetles and spiders.	Open-to-dense, moist conifer forests, and may be found in down wood and surface microrefugia. The species has been known to occur in disturbed areas, backyard wood piles, wood left after timber harvest or areas affected by wildfire.	Western Ore. and a small portion of northwestern Calif.
Klamath black	Up to 6.5		Open forest habitats, along with woodlands and grasslands that are generally moist and often have streams or seepages present.	Endemic to areas of southwestern Ore. and northwestern Calif.



SLENDER SALAMANDERS

Oregon slender salamander .... *Batrachoseps wrighti*
California slender salamander .... *Batrachoseps attenuatus*

As the names suggest, these two salamanders have long, thin bodies with tails that are equal (Oregon) or longer (California) in length than their bodies. Both have small, delicate feet with only four toes on their back feet, and tiny white flecks on their dark undersides. Both species are known to coil their bodies, which is thought to be a defense or escape mechanism, allowing them to roll easily off logs when disturbed by predators.

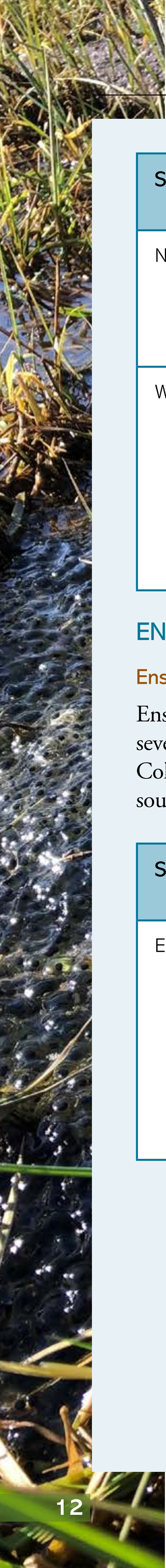
Species	Size (inches)	Diet	Habitat	Range
Oregon slender	About 4	Invertebrates such as snails, centipedes and spiders.	Oregon and California slender salamanders are both found in moist conifer forests in association with large down wood components, under thick bark or within decaying logs. Similar to the woodland salamanders, Batrachoseps have no aquatic life stage and lay their eggs in moist cavities of wood, soil or rock.	Primarily in the western slopes of Oregon's northern Cascade Range.
California slender	Up to 5.5			Coast Range of southwestern Ore., western and north-central Calif.

MOLE SALAMANDERS

Long-toed salamander .... *Ambystoma macrodactylum*
Northwestern salamander .... *Ambystoma gracile*
Western tiger salamander .... *Ambystoma tigrinum*

Mole salamanders are medium to large salamander species with stocky bodies that spend most of their time under leaf litter or burrowed underground. Species identification in aquatic habitats can be difficult, as mole salamander larvae are similar in appearance. As such, species are often distinguished by their egg masses, with northwestern salamanders laying a round, relatively hard mass, and long-toed salamander eggs laid singly (high elevations) or in small, loose clusters. Western tiger salamander eggs are similar to the long-toed salamander, but are lighter in color.

Species	Size (inches)	Diet	Habitat	Range
Long-toed	4 - 6.3	A variety of invertebrates, both aquatic and terrestrial.	Found in open grasslands, woodlands and conifer forests in areas with water present, usually still or slow-moving. Aquatic vegetation is a key component for all three species during breeding and for the larval form. They can breed in ponds, lakes and intermittent water bodies, including roadside ditches and forest swales.	Calif. to British Columbia and east to Alberta and Mont.



Species	Size (inches)	Diet	Habitat	Range
Northwestern	About 9.75	A variety of invertebrates, both aquatic and terrestrial.	Found in open grasslands, woodlands and conifer forests in areas with water present, usually still or slow-moving. Aquatic vegetation is a key component for all three species during breeding and for the larval form. They can breed in ponds, lakes and intermittent water bodies, including roadside ditches and forest swales.	Northwestern Calif. to British Columbia, in the Cascade Range and west in Ore.
Western tiger	Up to 13.75	Favors amphibian larvae in breeding ponds, but will eat most animals that are small enough.		They occur in patchy areas in Oregon including The Dalles, the Klamath Falls area and Moon Reservoir in Harney County.

ENSATINA

Ensatina..*Ensatina eschscholtzii*

Ensatina is a medium-size, terrestrial, lungless plethodontid salamander. This species is made up of seven subspecies that span the West Coast and Cascades from the Baja Peninsula to southwest British Columbia. Only two ensatina subspecies are found in Oregon: *E. e. picta*, in a small portion of the extreme southwestern part of the state, and *E. e. oregonensis*, throughout areas of the state west of the Cascades.

Species	Size (inches)	Diet	Habitat	Range
Ensatina	3 - 6	Invertebrates, including spiders, insects and millipedes.	Found in a variety of moist forested environments, both coniferous and conifer-deciduous mixed. Uses underground cavities or partially decayed logs for egg laying, and adults are known to occupy moist woody debris piles at the base of snags, moist talus with woody debris, and human-constructed surface debris in rural areas near forests, such as shingles, plywood or wood piles.	West of Cascade Range in Ore. The species' full range extends from the Baja Peninsula to southwest British Columbia.

NEWTS

Rough-skinned newt .... *Taricha granulosa*

This species is fairly large and easily identified by its bright orange underside, bulging eyes and grainy dark-brown back. Rough-skinned newts are highly toxic. They produce a lethal neurotoxin from dermal glands as a defense against predators. When threatened they will curl up and expose their orange bellies, and can cause incapacitation and death if eaten by predators such as garter snakes (Brodie et al. 2002).

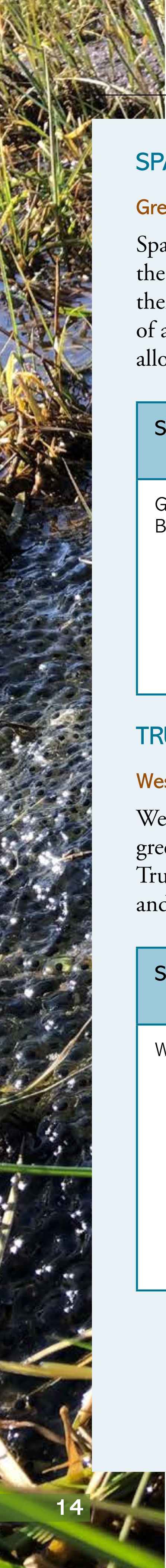
Species	Size (inches)	Diet	Habitat	Range
Rough-skinned	5 - 8.5	Primarily small invertebrates, but also will consume the eggs of other salamanders.	These newts are known to occupy a variety of habitats. Individuals have been observed from sea level up to 9,200 feet, in environments both wooded and open that have aquatic breeding still-water habitats present, such as lakes, ponds and stream pools or backwaters.	From northwestern Calif. up through western Ore., Wash. and coastal Canada, and into southeast Alaska.

TAILED FROGS

Coastal tailed frog .... *Ascaphus truei*
Rocky Mountain tailed frog .... *Ascaphus montanus*

Tailed frogs are the only amphibians in Oregon that have adapted to fertilize their eggs inside their bodies. This breeding tactic allows them to inhabit cold, quick-moving streams (Corkran 2006). Tailed frogs have also evolved specialized larval mouthparts that allow them to use suction to adhere to rocks and boulders, preventing them from being swept downstream. Their coloration matches their environment: a grainy brown to tan, sometimes with green, red or light blotches.

Species	Size (inches)	Diet	Habitat	Range
Coastal	Under 2	Aquatic larvae scrape diatoms and periphyton off stream substrates. Metamorphic froglets and adult frogs prey upon a variety of insects and other invertebrates.	Cold, flowing streams, generally observed in older forests. These frogs are sometimes found in upland forests as they disperse across a watershed.	Occur at higher elevations in Ore.'s Cascade and Coast ranges, with a range from northwestern Calif. to British Columbia.
Rocky Mountain	Under 2			Found only in far northeastern Ore., with a range extending to Idaho, Wash., Mont. and southern British Columbia.



SPADEFOOTS

Great Basin spadefoot .... *Spea intermontana*

Spadefoots are small toads with a gray or tan wide, fat body and short legs. These toads are named after the spade-shaped knob on the heel that is used for digging. They are known to be capable of concealing themselves entirely in the soil in just a few minutes. Spadefoots have one of the fastest development rates of all amphibians, metamorphosing in days rather than the weeks required by other frog species. This allows them to breed in temporary ponds and ditches as well as permanent freshwater sources.

Species	Size (inches)	Diet	Habitat	Range
Great Basin	About 2	Will eat just about anything, including other spadefoots! Larvae are omnivorous.	Generally associated with sagebrush flats and semi-arid shrubland habitat, this toad can also be found in pinyon-juniper woodlands. Breeding occurs in ephemeral ponds and ditches, as well as permanent freshwater sources.	East of the Cascade Range in the arid central and eastern regions of Ore., with a broader range extending across the western U.S. and into British Columbia.

TRUE TOADS

Western toad .... *Anaxyrus boreas*

Western toads are medium-size "true toads." They are mostly cream in color, with blotches of gray, red or green and a light-cream stripe down their backs. Western toad larvae are black and congregate in schools. True toads are a highly diverse group, and are widely distributed across the world. Their skin has a rough and warty look.

Species	Size (inches)	Diet	Habitat	Range
Western	About 5	Metamorphic toadlets and adults feed mainly on small terrestrial arthropods and other invertebrates. Larvae are omnivorous.	Found in a range of different habitats, including a variety of forest types such as conifer, hardwood and those with mixed tree species. They use ephemeral and perennial lakes and ponds, as well as slow-moving streams, for egg laying and larval rearing.	Largely distributed across Ore., the broader western U.S. and western Canada.

TREE FROGS

Pacific chorus frog (Pacific tree frog)..*Hyliola regilla*

Pacific tree frogs (chorus frogs) are the smallest of the frogs in Oregon, and have a large range of color variation. They generally appear bright green or pale tan, with long, dark blotches on their back and a dark stripe or mask extending from the nose to the shoulders. Larvae are brown. Pacific tree frogs are the only native frog in Oregon that vocalizes outside the water. Males use this advertising call to attract mates in the spring. They are known to remain underground, in streams/springs or in ponds during dry weather.

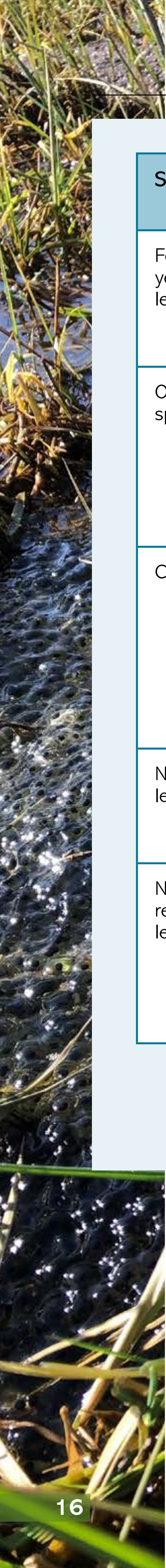
Species	Size (inches)	Diet	Habitat	Range
Pacific chorus	About 2	Adults are known to feed on beetles, flies, spiders, ants and an assortment of other invertebrates. Larvae are omnivores.	They inhabit a diversity of environments including hardwood, conifer and mixed woodlands. They are also found in disturbed areas such as clearcuts and other harvested areas. Tree frogs are pond-breeders, laying eggs in ephemeral or perennial ponds, lakes and wetlands, including roadside ditches and forest swales.	Well documented throughout Ore. Full range includes southeast Alaska, southwest British Columbia, the western U.S. to the Baja Peninsula and a number of isolated and island populations.

TRUE FROGS

Columbia spotted frog..*Rana luteiventris*
Foothill yellow-legged frog..*Rana boylii*
Oregon spotted frog..*Rana pretiosa*
Cascades frog..*Rana cascadae*
Northern leopard frog..*Lithobates pipiens*
Northern red-legged frog..*Rana aurora*

Ranidae is the family of “true frogs,” and is the most speciose and broadly distributed group of frogs in the world. They usually have long legs, narrow waists and smooth skin, and only the toes of the back legs are webbed.

Species	Size (inches)	Diet	Habitat	Range
Columbia spotted	Under 4	True frogs native to Ore. prey upon small invertebrates such as beetles, caterpillars and isopods. Larvae are omnivores.	Highly aquatic. Occupies ponds, lakes and slow-moving streams. Known to occasionally utilize upland habitats during wet weather.	East of the Cascade Range in Ore., with a broader western distribution in northwestern U.S. and into Canada.



Species	Size (inches)	Diet	Habitat	Range
Foothill yellow-legged	Just over 3	True frogs native to Ore. prey upon small invertebrates such as beetles, caterpillars and isopods. Larvae are omnivores.	Low to moderate elevations, usually in partially shaded perennial streams with exposed bedrock or rock and gravel substrates.	Forested regions of Southwestern Ore. are the current stronghold for this species across its broader range.
Oregon spotted	About 4		Always found in association with permanent bodies of water, and adults use microhabitats with dense vegetation in close proximity to water sources. Absent from dry uplands.	East of the Willamette Valley into the Cascade Range and south to the Klamath Valley in Ore. Also occurs in Wash. and southwest British Columbia.
Cascades	About 3		Moist mountain meadows and forests, and along streams and pond edges in the summer. Pond and lake breeding habitats are used upon snowmelt, and metamorphic froglets and adults may be found at cold springs or creeks.	Ore. Cascade Range. Range extends into Wash. and Calif.
Northern leopard	Just over 5		Preferred habitat includes riparian areas in moist forests, open woodlands, marshes and ponds with rooted aquatic vegetation.	Known to occur in far eastern Ore., with a broader distribution in the U.S. and Canada.
Northern red-legged	About 5.5		Ponds, marshes and still bodies of water, and have also been observed in damp meadow and woodland environments during wet weather away from water sources. Populations occur in lowland forests.	West of the Cascade Range in Ore., with a broader range extending from northwestern Calif. to British Columbia.

The American bullfrog

The American bullfrog (***Rana catesbeiana***, formerly ***Lithobates catesbeianus***) is an invasive amphibian found in low elevations throughout Washington and Oregon. Bullfrogs are aggressive predators of other amphibians, fish and turtles, and can outcompete native amphibians for resources necessary for survival. Bullfrog harvest is encouraged, and controlling their population is important for some native amphibian and fish populations.

3.0 Research advances addressing forest amphibians

Recent and ongoing research projects explore forest habitat associations of amphibians, and the impact of diverse management strategies on these forest-dwelling animals. Here we summarize these studies, focusing on riparian buffers, headwater streams, climate change, microclimates and connectivity.

3.1 RIPARIAN BUFFERS

Riparian buffers are planned by forest managers to protect streams during forest management activities such as thinning and clearcut harvest. Research on alternative streamside riparian buffer approaches in managed forests continues to be an active area of ongoing work. For example, the Density Management and Riparian Buffer Study (DMS) of western Oregon has been ongoing since the early days of the Northwest Forest Plan (NWFP) and its Aquatic Conservation Strategy (ACS) in the 1990s. Olson et al (2014) and Olson and Burton (2014) studied amphibian responses to different riparian buffer types (no-entry and thinned) and widths (e.g., 20 feet, 50 feet, 230 feet), combined with alternative upland forest management techniques (e.g., upland thinning treatments). Amphibians were not a leading concern when riparian buffers were first designed and integrated into forest management practices, but recent publications have shed light on the ways in which forest amphibians benefit from buffers.

Riparian buffers are planned by forest managers to protect streams during forest management activities such as thinning and clearcut harvest.

Riparian buffers are a core tenet of the ACS portion of the NWFP, which has been policy now for nearly three decades on federal lands in western portions of Oregon, Washington and California. In a major report that summarized the science published since the implementation of the NWFP and ACS in 1994, Reeves et al. (2018) came to a number of conclusions regarding the use of riparian buffers. Overall, they found that the scientific basis for the use of riparian buffers in maintaining aquatic-riparian species such as fish and amphibians is valid. They also stated that recent science raises questions about if and how to implement the ACS differently, how more active management in riparian buffers may be beneficial in some cases, and how narrower buffers may be adequate to achieve ACS goals for protecting fish-bearing streams. Reeves et al. (2016) conducted a significant evaluation of riparian buffer practices and put forth two possible options for refining their use – one being a fixed-width approach to inner and outer buffers, and the other a context-dependent approach. Amphibians were a key consideration in designing these potential options, which also sought to incorporate other goals such as timber harvest. In particular, they took into account recent research regarding forest amphibians' tendency to travel along small streams, as well as how forestry activities affect stream microclimates upon which amphibians depend. Ultimately, though both of the presented options would reduce the area of current buffers, the authors believed aquatic-riparian species would still be maintained or restored by incorporating ecological forestry (e.g., thinning) within the outer buffer area and tree-tipping to ensure wood recruitment to the stream.

Studies examining how the use of variable widths of stream buffers directly affects amphibians are important, because this information can help managers determine how wide buffers should be to meet ecological and economic goals. Olson et al. (2014) reported relationships between different

buffer widths and stream-associated vertebrates at sites in western Oregon over 15 years, including surveys of pre-thinning treatments and 10 years after. These surveys took place in secondary forest sites (stands were 30 - 70 years old) that were originally clearcut without any stream buffer. All study species persisted at sites in the decade following the stream-adjacent thinning treatment. This suggests an apparent resilience of riparian forest amphibians, and that the timber harvest did not cause serious, lasting species declines or extirpations in that time. They did, however, document some evidence of reduced counts of bank-dwelling amphibians after timber harvest where buffers were narrower, particularly the 20-foot buffers. This suggests that a 20-foot buffer may not be sufficient to provide habitat for some amphibian species during timber harvest. Olson and Burton (2014) observed the impacts to stream-associated vertebrates from a second thinning treatment, 12 years after the first, adjacent to stream buffers of varying widths. They reported conservation value from maintaining medium to wide buffers (50 feet or more) on headwater streams, as some amphibian species were found to have higher counts with these buffer widths within the study duration. However, they found significantly lower counts of some species declined in the narrowest buffer treatment (20 feet). Notably, their findings suggest that variable-width buffers with a minimum of 50 feet that are not thinned may be sufficient to support sensitive headwater stream amphibians, provide short- and long-term ecological benefits, and present a practical way for land managers to provide amphibian habitat in riparian buffers. Timber harvest has a delayed effect on amphibians, and monitoring continues to assess long-term impacts.

Wood pieces and logs that make their way into or adjacent to headwater streams play a number of important roles in stream dynamics, and serve to provide habitat for amphibians and other small animals. Burton et al. (2016) reported on a 14-year study in western Oregon that assessed the relationship between no-cut riparian buffer width and in-stream wood loading (how much wood ends up in a stream) in thinned forests. More than 80% of sourced in-stream wood came from within 50 feet of the stream, and the highest volumes of newer wood were seen at streams with the narrowest (20-foot) buffer. This finding ran contrary to the authors' predictions, and indicated that, at least in the short term, thinning closer to streams may boost wood recruitment. However, most wood overall was old and in later stages of decay, and more than 50% of older wood could not be sourced at all. This hints at the slowness and complexity of wood delivery to streams, especially in the absence of larger trees within younger managed stands. The authors expressed concern over future deficits of in-stream wood in managed forests as older pieces break down and loss outpaces recruitment. They stated that their results underscore the importance of leaving old, large wood pieces, and suggested that practices such as directional felling, thinning to encourage growth of large trees, and large wood creation may be needed to maintain desired instream wood volume.

What does this mean for management?

Implementing practices such as thinning and tree-tipping along riparian buffers may serve to allow timber harvest while also maintaining the corridor effect of streams and essential microclimates for amphibians. These approaches may also improve streamside forest habitats by accelerating development of large trees and old-forest conditions, which can be important for future large down wood recruitment. Keeping at least a narrow buffer along streams helps ensure wood recruitment into the stream, and stream shading to forestall water temperature increases. Leaving legacy wood and recruiting older structure within riparian areas is essential for amphibians.

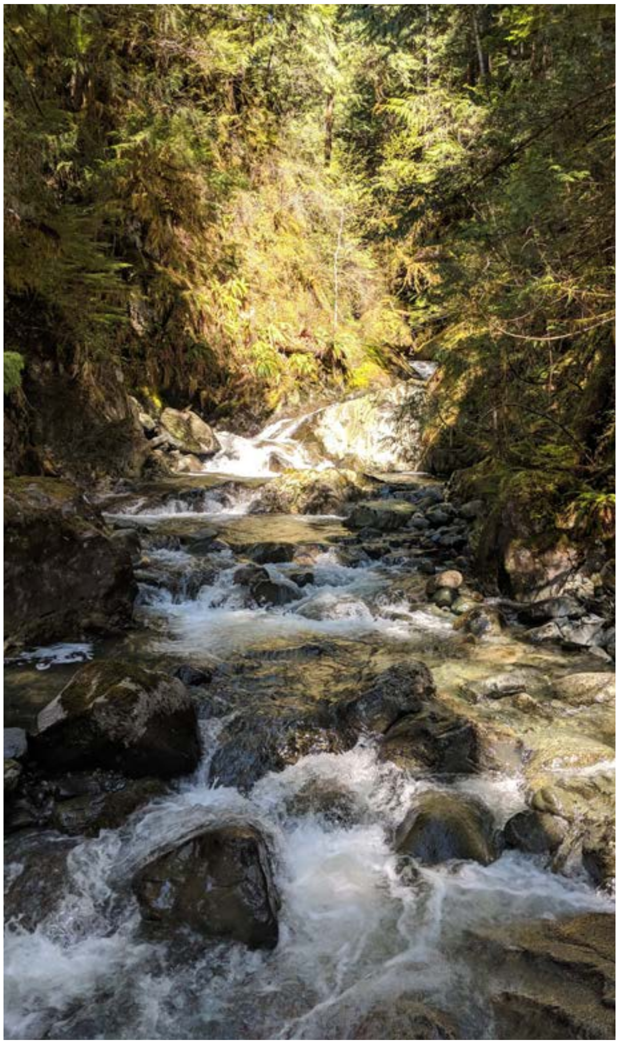
Oregon Forest Practices Act

Land managers should review the Oregon Forest Practices Act for more information on required buffer widths. Management suggestions included here are suggestions only, and are not policy recommendations. A valuable resource is the OFRI *Oregon's Forest Protection Laws - An Illustrated Manual,* available at OregonForests.org

3.2 HEADWATER STREAMS

Headwater streams are vital water sources. They influence the quality of downstream reaches by transporting nutrients and down wood from forested highlands to lower parts of the watershed. Headwaters and other small streams provide most of the drinking water in the continental United States, and play a major part in the life cycles of fish such as salmon. Many forest amphibians rely on the cool, flowing and highly oxygenated water of these streams throughout their life stages for breeding, foraging and dispersal.

Stream-associated forest amphibians in the Pacific Northwest are cryophilic, meaning they rely on cold water to survive. Headwater streams are naturally variable through time and setting, and experience natural seasonal temperature fluctuation, but factors such as human activities and climate change may influence these fluctuations to the point that temperature thresholds are passed more often or for longer duration. A stronger understanding of how stream temperatures change throughout the year, and how they are influenced by site characteristics such as topography, hill-shading, and cold water inputs and human activity, can help better predict stream amphibian distributions and assess threats.



Many forest amphibians rely on headwater streams such as this one throughout their life stages for breeding, foraging and dispersal.

Leach et al. (2017) conducted a two-year survey of headwater stream temperatures in a managed forest site in western Oregon. They found that stream temperatures varied across the entire network, and were especially variable during summer and cold, dry winter periods. They noted that variation was observed at smaller scales than regional models are able to predict, and was influenced by site characteristics that affected how much sunlight hit the water surface. There was not, however, an effect of buffer width on stream temperatures in this study, which was conducted with thinned forests upland of buffers.

What does this mean for management?

Recognizing seasonal patterns of temperature fluctuation and local habitat characteristics may be important when considering distributions of amphibians in headwater streams. Managing to retain cold-water refuges for stream amphibians and salmon is an emerging consideration.

Headwater streams

Headwater streams are the smallest parts of river and stream networks, but they make up the majority of river miles. They are the part of rivers farthest from the river's endpoint or confluence with another stream. Headwater streams often have seasonal or intermittent flow at their upper reaches, but can still provide key functions and habitat for stream amphibians. Headwater streams can range from seasonal upper reaches to small streams with perennial flow.

3.3 CLIMATE CHANGE

Amphibians are known to be sensitive to changes in their surroundings, and are generally considered to possess traits (e.g., skin that must remain moist, dependence on multiple hydrologically sensitive habitat types throughout their complex life histories, and low relative mobility) that make them particularly vulnerable to increases in warming, drying and extreme weather events. The changing climate is a looming and potentially existential threat for many species. Although climate change is a widely researched topic, there is a need for further research on how climate change impacts forests and wildlife management. Efforts by researchers to analyze and predict the effects of climate change are providing us with an ever-clearer picture of the challenges we might expect for forest amphibians in the Pacific Northwest.

Retaining legacy features such as this stump may be an effective strategy for maintaining critical microhabitats for amphibians.

Notable scientific efforts with direct implications for management include modern re-examinations of major environmental protection efforts such as the ACS of the NWFP, which wasn't originally designed with climate change as a main consideration. Additionally, Olson, Coble and Homyack (2021) are looking past the standards of today's best management practices toward more robust approaches to stream management in forests that not only seek to achieve regulatory compliance but also consider the long-term health of ecosystems while accounting for the evolving understanding of threats posed by climate change. Management considerations for climate change were explored by Olson and Burnett (2013), who found reduced headwater stream flow in recent warm, dry summers, with additional reductions in future years with climate change projections. Among other things, they suggested focusing conservation management efforts on key biodiversity stronghold areas such as headwater streams within forested riparian landscapes, maintaining connectivity between these strongholds, and providing habitat redundancy to help preserve species that may be forced to migrate due to climate change and catastrophic events. Frey et al. (2016) looked at the potential for forests with legacy features to buffer against climate change and compared that potential to older managed forests. Their findings suggested that legacy characteristics were associated with lower and more stable temperature regimes in the understory.

What does this mean for management?

Climate change is becoming a top consideration for forest managers and landowners making conservation decisions, even though there are still many unknowns. A focus on biodiversity refugia and providing redundancy is a foundational conservation strategy. Retaining legacy features and maintaining a diversity of trees species may be an effective strategy for maintaining critical microrefugia and associated biodiversity under climate change (Frey et al., 2016).

3.4 MICROCLIMATES

Amphibians are often found under leaf litter, or in and under down wood.

The interaction of topography, forest type, stream conditions and climate can result in small-scale refugia and local characteristics that can differ substantially from regional climate regimes. Those differences can be critically important to wildlife, especially less mobile, environmentally sensitive animals such as amphibians. A favorable microclimate, which may be found within the forest canopy, beneath a log or surrounding a cold stream, provides refuge from less favorable surroundings. Shade, cool temperature and moisture are basic qualities that help make up a suitable microclimate for forest amphibians. The day-to-day survival of amphibians, as well as their capacity to adapt to disturbance within their habitat such as timber harvest or climate change, hinges largely on their ability to find and make use of these refugia.

Among the better-studied amphibian refugia are coarse woody debris (CWD) and simply larger down wood pieces and logs in a forest, which provide physical cover and a favorable microclimate for terrestrial amphibians. Garcia et al. (2020) in part looked at associations between CWD and two salamander species in Oregon during harvest treatments versus a control, and examined how forest management activities affected the CWD itself. Not only did they see a positive association between salamanders and the amount of CWD within a stand, they found that ambient air as well as internal temperatures of down wood were warmer in recently logged areas compared to control stands. However, down wood in these areas still had a cooler internal temperature relative to the open air. These findings suggest that while down wood in logged areas does provide a relatively cooler microclimate, the wood's capacity to buffer against ambient air temperature was reduced, likely due to loss of canopy cover. Kluber et al. (2009) also studied the role of down wood as thermal refugia for salamanders, citing the trend of reduced large-wood recruitment and advanced decay of existing large logs from managed forests in the context of unharvested riparian buffers and upslope thinning, as a need to better understand the efficacy of smaller CWD for amphibians. Their results showed that logs of a wide size variety (not just large logs), soil and streamside temperatures remained cool enough to likely shelter salamanders even on very hot summer days. The authors noted additional concerns, however, about using smaller wood pieces as thermal refugia in conservation decisions. Since smaller wood pieces dry out and decompose faster, forest managers may want to increase the rate of recruitment or maintain additional canopy cover.

Oregon State University researchers found a positive correlation between salamanders and the amount of down wood within a stand. They also found that down wood temperatures were cooler relative to the open air.

What does this mean for management?

Maintaining legacy features may help preserve favorable microclimates and provide habitat refugia for forest-dwelling amphibians. Down wood is a critical refuge type for forest amphibians. Larger logs provide a more thermally stable and long-lasting refuge, but smaller wood pieces can potentially be adequate. However, if smaller wood is being used as refugia it may need to be replenished more often, and its usefulness may be reduced if the site lacks canopy cover. Woody debris on the ground provides necessary microclimate for forest amphibians, but is likely most effective when the wood has some canopy cover above it.

Connecting forested habitats over ridgelines and along waterways is beneficial for many species, including the ensatina shown here.

3.5 CONNECTIVITY

For wildlife species to persist, they must be able to move from one location to another to fulfill their life histories. Habitat connectivity is also important in order to increase genetic variability within populations. Amphibians often have aquatic and terrestrial phases, each with unique requirements for survival as they transition from egg to larva to breeding adult. Habitat connectivity, and designing a pattern of forest management across landscapes to maintain it, is becoming a highly active research topic. In their review of the relevant science since the implementation of the NWFP and ACS in the 1990s, Reeves et al. (2018) stated that federal lands alone likely cannot meet conservation goals set forth by these policies, due to the patchwork nature of land ownership. Waterways and wildlife dispersal corridors often span multiple habitats and multiple ownerships, often with wide-ranging management goals. Maintaining and restoring aquatic-riparian forest species is an endeavor that benefits immensely from multi-ownership participation. This position is in part based on recent research exploring how amphibians disperse and move around the landscape, and the barriers that impede them.

Landscape genetics studies greatly broaden our understanding of how features of the landscape influence genetic structure and gene flow, or movement between populations, by testing any number of environmental variables against these genetic measures of population health. Distance is one big factor for population isolation and reduced genetic variation, especially for small animals such as frogs and salamanders. These studies demonstrate how many factors, such as vegetation changes or roads built through habitat, create barriers to gene flow and thus reduce the genetic diversity of populations. Emel et al. (2019) looked at how forest cover and other factors influence genetic diversity in torrent salamanders at sites in the Pacific Northwest. Results indicated that roads and forest fragmentation can be major barriers to dispersal, and suggest that forest cover is essential for dispersal. The authors would like to see this work used to help design connectivity pathways in managed forest landscapes, as it reinforces the idea that many aquatic-riparian species benefit from forested corridors along streams and over ridgelines. They say these ideas will likely be essential to the conservation of high-risk species such as torrent salamanders. Todd et al. (2009) observed similar preferences for dispersal through forested habitat by pond-breeding amphibians in the southeastern U.S., though it was observed to be stronger in salamanders than frogs. Preserving forest habitat around reproduction sites and maintaining forested corridors between those sites and other habitat areas were deemed especially important.

In a synthesis of connectivity research, Olson and Burnett (2014) made a number of suggestions for incorporating habitat linkages into managed landscapes. Among the main landscape-scale connectivity considerations they put forward is the idea of redundancy. Providing wildlife with multiple options for dispersal helps guard against major events and uncertainty. Having redundant connectivity corridors with quality refugia is likely to be especially beneficial to slow-moving, environmentally sensitive animals such as amphibians. Olson, Coble and Homyack (2021) noted the importance of maintaining connectivity for animals such as amphibians that have many different habitat requirements based on life-history stage (breeding, foraging and dispersing). Without the ability to move from one critical area to another, a population would likely suffer. Considerations such as this are key in steering the evolution of best management practices.

What does this mean for management?

Forested linkages between habitats, over ridgelines and along waterways are highly supported by research. Redundancy helps protect against disastrous events and aids successful movement. It is essential to consider the physiological constraints of amphibians (slow, sensitive to heat and desiccation, needing multiple habitat types) when designing and maintaining corridors. It is vital to understand that it may take forest amphibians a relatively long time to move, and that all along the way they need refugia such as down wood to provide them with the conditions needed for survival. Also, it's beneficial to provide connectivity across roads and clearcuts, as these could be barriers to physical movement and gene flow.

Rhyacotriton kezeri (upper left), rough-skinned newt (upper right), Larch Mountain salamander (lower right), clouded salamander (lower left).

4.0 Practical approaches to retaining and restoring forest amphibian habitats

Managed forests have a tremendous opportunity to provide the key components necessary for forest-dwelling amphibians. Society's needs for lumber and other forest products are large and seem to increase annually, with privately managed forests providing the largest percentage of timber for forest products. Contributing to the world's wood supply while still promoting biodiversity on the landscape is challenging, but essential. The following section summarizes laws related to amphibian habitat components and offers further suggestions for improving habitat for forest-dwelling amphibians. Following the law and implementing one or more of the following suggestions when managing forests will go a long way toward conserving this important group of organisms.

In 1971, Oregon became the first state to pass a comprehensive law to regulate forest practices and help safeguard water, fish and wildlife habitat, soil and air. The rules of the Oregon Forest Practices Act are continually reviewed and updated. For timber harvest units greater than 25 acres, landowners must do the following for wildlife:

- Leave standing live trees or snags, at least two per acre of harvest, each at least 30 feet tall and 11 inches in diameter.
- Leave at least two logs on the ground per acre of harvest, each at least 10 cubic feet.

This could be considered a minimum for leave trees and down wood. Note that safety is a consideration when determining where to retain live standing trees and snags, as these can be a hazard.

Down wood

Dead and down woody material in the form of root wads, bark, limbs and logs have critical functions in the forest ecosystem. This material is important in nutrient cycling, natural regeneration and habitat for many wildlife species, including amphibians. Down wood wildlife habitat considerations during timber harvest include:

- Avoid harvesting or moving large-diameter logs intended for down wood to landings. Instead leave large-diameter down wood undisturbed and distributed naturally throughout the timber harvest unit.
- Keep large-diameter down logs distributed throughout harvest units instead of piling them into slash piles, where practicable.
- Leave large-diameter logs during commercial thinning operations. This will increase the amount of down wood as the stand ages.
- Avoid mechanical damage of existing down logs and retain them on the landscape.
- Place skid trails to avoid large down wood when possible, and when not feasible, move the large down wood to the side, minimizing disturbance to the log.
- Look for opportunities to use un-merchantable portions of large-diameter logs as down wood, placing it within the unit and away from landings.
- Retain unmerchantable, smaller-diameter down wood throughout regeneration and commercial thin units.

Habitat management guidelines

Additional habitat management guidelines have been developed by Northwest Partners for Amphibian and Reptile Conservation (NWPARC) and are available for download: nwparc.org/products.

Snags and legacy trees and stumps

As with down wood, standing dead trees, or snags, are hugely important for amphibians. The following management strategies may be useful for snag recruitment:

- Retain existing snags where safe to do so.
- Leave "extra" wildlife trees for future snag recruitment (consider leaving the large-diameter wildlife trees that are of low economic value).
- Retain existing legacy trees and stumps.

Buffers

The Oregon Forest Practices Act has specific requirements for logging near streams. Many times, unharvested buffers of trees are required along fish streams. Riparian buffers also contribute to critical habitat elements for amphibians. Leaving riparian buffers along streams, including non-fish-bearing and headwater streams, can help provide important habitat for amphibians. In addition, managers may include protection of stream-associated seeps and wetlands when designing stream buffers. Researchers are currently studying alternative riparian management practices and the impact of riparian buffers on healthy stream function.

Connectivity corridors

Research supports maintaining forest cover between habitats, over ridgelines and along waterways as conservation measures for forest amphibians. Consider the physiological constraints of amphibians (slow, sensitive to heat and desiccation, needing multiple habitat types) when designing corridors. Forest amphibians disperse slowly and need refugia, such as down wood, along the way to provide the necessary conditions for survival.

Retaining down wood within stands is highly beneficial for forest amphibians.

Retaining snags (where safe) is hugely important for forest amphibians.

5.0 Summary

Managed forests provide important habitat for forested amphibians in Oregon. Land managers have an opportunity during timber-harvest planning to provide for amphibians by considering riparian buffers, placing required wildlife trees in ways that provide movement corridors for amphibians, and considering the placement of down wood during management activities. Science supports the importance of managing in a way that supports amphibians while still providing forest products for Oregonians.

6.0 Resources

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