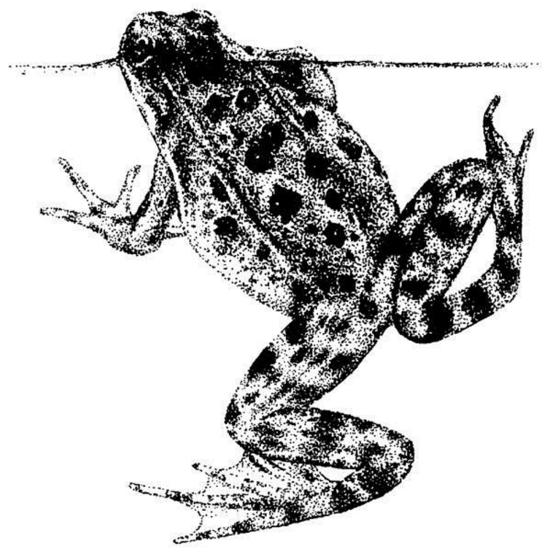
DRAFT

State of Washington

Oregon Spotted Frog Recovery Plan



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In 1990, the Washington Wildlife Commission adopted procedures for listing and de-listing species as endangered, threatened, or sensitive and for writing recovery and management plans for listed species (WAC 232-12-297 [Appendix A]). The procedures, developed by a group of citizens, interest groups, and state and federal agencies, require preparation of recovery plans for species listed as threatened or endangered.

Recovery, as defined by the U.S. Fish and Wildlife Service, is the process by which the decline of an endangered or threatened species is arrested or reversed, and threats to its survival are neutralized, so that its long-term survival in nature can be ensured. Washington Department of Fish and Wildlife has adopted this definition.

This is the Draft State of Washington Oregon Spotted Frog Recovery Plan. The preliminary draft has undergone agency and scientific review. It summarizes what is known of the historical and current distribution and abundance of Oregon Spotted Frog populations in Washington and describes factors affecting these populations and occupied habitat. It prescribes strategies to recover the species, such as protecting populations and existing habitat, evaluating and restoring habitat, developing potential reintroductions of Oregon Spotted Frogs into vacant habitat and initiating research and cooperative programs. Target population objectives and other criteria for reclassification are identified.

As part of the State's listing and recovery procedures, the draft recovery plan is available for a 90-day public comment period. Please submit written comments on this report by August 9, 2013 via e-mail: TandEpubliccom@dfw.wa.gov or by mail to:

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EXECUTIVE SUMMARY

The Oregon Spotted Frog is a medium-sized aquatic frog endemic to the Pacific Northwest. Historically, it was distributed from southwestern British Columbia, Canada to northeastern California. Today there are approximately 46 locations in British Columbia, Washington and Oregon. In 1997, the U.S. Fish and Wildlife Service concluded that federal listing of the Oregon Spotted Frog as Endangered or Threatened was warranted but precluded from listing by other higher priority species. It is currently a Federal Candidate Species.

The Oregon Spotted Frog was listed as Endangered in Washington in 1997 by the Washington Fish and Wildlife Commission. Museum specimens and substantiated accounts indicate Oregon Spotted Frogs were found in both the Puget Trough and East Cascades ecoregions. The species is known to persist in only six Washington river drainages: Sumas River (Whatcom County), Black Slough (Whatcom County), Samish River (Whatcom & Skagit Counties), Black River (Thurston County), Trout Lake Creek (Klickitat and Skamania Counties) and Outlet Creek at Conboy Lake and Camas Prairie (Klickitat County).

The decline in the occurrence and population sizes of Oregon Spotted Frogs is attributable to several major human-caused stressors. These include:

- Wetland loss and alteration.
- Loss of disturbance processes that set back succession.
- Introduction of non-native/invasive flora and fauna (e.g., reed canarygrass, bullfrogs, game fish).
- Alteration of creek and river channels.

Oregon Spotted Frogs have specific life history traits, habitat requirements, and population characteristics that limit their distribution and make them vulnerable to these changes. These include:

- A completely aquatic life history.
- Communal reproduction concentrated on the landscape with the same localized breeding areas used annually.
- High levels of population fluctuation.
- Dispersal limited to aquatic corridors.
- Association with relatively large permanent wetlands (typically > 4 ha) that include shallow, warm-water habitats.
- Breeding habitats that have shallow water ($\leq$ 30 cm), short vegetation and full sun exposure with relatively stable hydrology and aquatic connectivity to permanent waters.
- Overwintering habitats that provide adequately oxygenated water and shelter from freezing conditions and predators.

Additional threats include the geographic isolation of Oregon Spotted Frog populations and the increase of water-borne pollutants and diseases. This list of threats is neither exhaustive nor independent, as a number of factors are interconnected. Climate change is a looming threat of concern because it involves potential changes likely to have severe effects on Oregon Spotted Frogs across their geographic range.

Given the trajectory of habitat change and interrelated conditions that threaten this species, Oregon Spotted Frogs in Washington are not expected to recover without intervention. Habitat management will be an essential part of the recovery plan for this species. To downlist the species, habitat conditions will need to be improved at occupied sites to enhance population numbers and new populations may need to be established or found. This will require the cooperation of many landowners, partners, and other

stakeholders. The expertise and facilities provided by zoos and aquariums will also be valuable in these efforts.

The Recovery Plan identifies two recovery zones in Washington: the Puget Trough Ecoregion and the southern portion of the East Cascades Ecoregion. The recovery strategies focus on monitoring and protection of remaining populations, enhancement of occupied habitat through species-specific adaptive habitat management, research to facilitate and enhance recovery, inventory for undiscovered populations and re-establishment of populations within the historical range. Sources of funding for these efforts will need to be identified and secured. The recovery objectives identified in this Plan may be modified as more is learned about the habitat needs and population dynamics of Oregon Spotted Frogs.

Recovery Objectives

The Oregon Spotted Frog will be considered for downlisting to Threatened when the following conditions are achieved:

1. **Washington has populations in at least six drainages that produce a total of ≥7,500 egg masses annually and each drainage supports a minimum of 500 egg masses from frogs close enough in distribution to exchange genes. These population levels must be met in 7 of 10 years sampled. A declining trend in the last three years would result in an extension of the sampling period for three additional years to verify that the populations are stable or increasing.**

2. **At the time of downlisting, at least one recovery zone supports a minimum viable population.**

3. **Management plans and funding are in place to maintain suitable habitat at each occupied site within the six drainages over the long-term.**

The Oregon Spotted Frog will be considered for downlisting to Sensitive when the following conditions are achieved:

1. **Washington has populations in at least six drainages that produce at total of ≥10,000 egg masses annually and each drainage supports a minimum of 500 egg masses from frogs close enough in distribution to exchange genes. These population levels must be met in 7 of 10 years sampled. A declining trend in the last three years would result in an extension of the sampling period for three additional years to verify that the populations are stable or increasing.**

2. **At the time of downlisting, both recovery zones support a minimum viable population.**

3. **Management plans and funding are in place to maintain suitable habitat at each occupied site within the six drainages over the long-term.**

The recovery strategies outlined in this plan are based on current conditions and scientific knowledge. The status of Oregon Spotted Frog populations and the recovery strategies will be reviewed every five years to determine if recovery objectives have been met and if new recovery approaches are warranted.

After the species is downlisted to Sensitive, a management plan will be prepared that includes the recovery objectives to delist the species.

INTRODUCTION

The Oregon Spotted Frog (*Rana pretiosa*) has declined in numbers throughout its range and has been extirpated from large portions of its historical distribution. Range loss is estimated to be 79% but may approach 90% (Hayes 1997a). Available evidence indicates the species has been extirpated from the southern portion of its range in California and the lowland Willamette Valley in Oregon, and the fate of populations at the northern extreme of the range in Canada is precarious (Hayes 1997a, Haycock 2000). Approximately 46 occupied sites are known to persist in Oregon (32), Washington (10) and British Columbia (4) (USFWS 2011, Bohannon et al. 2012).

Museum specimens collected in Washington document an historical distribution in the Puget Trough lowlands and southern Washington Cascades (McAllister 1995, McAllister and Leonard 1997). Current known distribution of Oregon Spotted Frogs is limited to six isolated populations located in Whatcom (Sumas River, Black Slough, and Samish River), Skagit (Samish River), Thurston (Black River) and Klickitat (Trout Lake and Conboy Lake) counties. The Trout Lake population complex includes a beaver pond that occurs in Skamania County.

The Washington populations are vulnerable because of isolation, fluctuating population sizes, invasion of non-native flora and fauna, diseases, localized landscape perturbations, and climate changes. The species was added to the state list of endangered species in 1997 and is a candidate for listing under the Federal Endangered Species Act. This recovery plan updates information from the 1997 Washington Department of Fish and Wildlife (WDFW) status report (McAllister and Leonard 1997), identifies population recovery objectives and outlines activities needed to recover Oregon Spotted Frog populations in Washington.

TAXONOMY

The Oregon Spotted Frog is classified in the Order Anura, the Family Ranidae (true frogs) and the genus *Rana*. Baird and Girard (1853) described *R. pretiosa* from specimens collected from “Puget Sound.” Two significant taxonomic changes have occurred since *R. pretiosa* was described. Slater (1939) described *R. cascadae* (Cascades Frog) as a unique species morphologically distinct from *R. pretiosa*. The split became well-accepted with support from Dunlap (1955). Green et al. (1996) first recognized genetic divergence among populations of spotted frogs and Green et al. (1997) formally recognized two spotted frog species subsequently called Oregon Spotted Frog (*R. pretiosa*) and Columbia Spotted Frog (*R. luteiventris*).

DESCRIPTION

Figure 1. Oregon Spotted Frog (*Photo by K. McAllister*).

The Oregon Spotted Frog is a medium-sized, aquatic, ranid frog (Fig. 1). Adult size is 44 to 107.5 mm (1.25–4.23 in.) snout-vent length (SVL) (Stebbins 2003, Rombough et al. 2006). Females grow to larger sizes than males. Variation in size has been noted among populations, but its basis is unclear. In lowland British Columbia and western Washington (~15 m–42m [49-138 ft.] elevation), the maximum size of males and females did not exceed 66 mm and 89 mm SVL respectively (Licht 1986b and McAllister and Leonard 1997). At Conboy Lake, located at an elevation of 1,548 m (1,800 ft.), Rombough et al. (2006) measured 43 frogs that exceeded 100 mm (~ 4 in.) SVL.

Characteristics of the head include upward oriented eyes that are yellow-green (chartreuse) in color, a pointed snout, a white lip line, and an eye mask (Stebbins 2003, Jones et al. 2005). The eye mask may be faint. The dorsal coloration is brown to brick red. Spots are present on the head and back. Dorsal spots on adults vary but are typically relatively large, black, irregularly shaped, ragged-edged, and light centered (Nussbaum et al. 1983, Stebbins 2003, Jones et al. 2005). The spots may be obscured when the skin is darkened. The amount of red pigmentation on the dorsum varies by population with frogs in Klickitat County having noticeably more red pigmentation than those in Thurston, Whatcom and Skagit counties. The amount of red pigmentation also increases as the frog ages (McAllister and Leonard 1997). Dorsolateral folds are present but may be indistinct or extend only partially across the back. In particular, posterior to the sacral hump, the folds may be absent, discontinuous or indistinct.

Figure 2. Ventral view of newly metamorphosed Oregon Spotted Frog

At metamorphosis, ventral coloration is white or cream (Fig. 2). Red-orange pigment develops as the frog grows (usually present by >40 mm SVL; Hayes 1997a) and is concentrated primarily on the ventral surfaces of the legs, sides of the abdomen and lower abdomen (Fig. 3). Dark mottling on the abdomen and chin also develops with age (Hayes 1994a). Physiological changes result in more or less concentrated pigmentation such that the dark mottling on the abdomen decreases when individuals either are excited or have an elevated body temperature (Hayes 1994a, 1997a). In the groin region, the darker pigmentation of the dorsal surface gradually blends to lighter pigmentation on the ventral surface; no distinct patch of black, cream, and yellow-green mottling is present in the groin as typically occurs in Northern Red-legged Frogs (*R. aurora*; Fig. 3). The light orange ventral coloration described in some Oregon populations (e.g., Jack Creek; Hayes 1997a, C. Pearl, pers. comm.) has not been observed in Washington.

Figure 3. Groin coloration and pattern difference between Northern Red-legged Frog (left) and Oregon Spotted Frog (right) (*Photo by D. Hagin and L. Hallock*).

The legs are relatively short. The lower leg (fibula-tibia) is almost always less than half the body length (Hayes 1994a). Webbing on the toes of the hind foot extends almost to the toe tips. Sexually mature males (≥ 45 mm SVL or larger in Oregon [C. Pearl, pers. comm.]) develop permanent nuptial pads (excrescences) on the thumbs (prepollex) as well as more developed forelimb muscles (Fig. 4).

Figure 4. Nuptial pad (Photo by D. Hagin and L. Hallock).

Vocalization. Males lack vocal sacs (Hayes and Krempels 1986). As a result, the call is weak especially when calls are produced in air. The advertisement call sounds like faint, rapid, low-pitched tapping (Stebbins 2003). The calls seem distant even if one is in close proximity to calling males; similar to the sound of hammering at a distant construction site. Davidson (1995) and Elliott et al. (2009) provide recorded calls as does the online site CaliforniaHerps (2011).

Eggs. The egg mass is compact and globular (Licht 1971a, Fig. 5). It is 12-20 cm (~ 5–8 in.) in diameter when fully expanded (Nussbaum et al. 1983). Variation in swelling of the individual capsules within the mass can occur due to ionic (pH) concentration in water (Duellman and Trueb 1986). The animal pole of the egg (ovum) is darkly pigmented and appears black (actually dark brown) as do the embryos. The ovum averages 2.31 mm in diameter (n = 292, SD = 0.18; Licht 1971a). Egg masses examined from lowland Canada and Washington sites had an average of 598-643 ova per egg mass (Licht 1971a, McAllister and Leonard 1997). Larger numbers of ova have been found in egg masses from high elevation sites in Oregon (C. Pearl, pers. comm.).

Figure 5. Egg mass (*Photo by T. Hicks*).

The female nestles her egg mass into submerged vegetation or lays it on top of or adjacent to other Oregon Spotted Frog egg masses in water less than 30 cm (12 in.) deep. The egg mass typically protrudes above the water surface when first laid

(Licht 1969; Fig. 6). Communal deposition and aggregation of egg masses is typical (Licht 1969). The number of overlapping clustered egg masses can range from 2 to ≥ 100 (Leonard 1997, Cushman and Pearl 2007). Larger communal egg mass clusters can exceed a meter (3 ft.) in diameter (L. Hallock, pers. ob.). The propensity for females to clump or scatter egg masses varies by population and is poorly understood. The Black River subpopulations aggregate the majority of egg masses in overlapping communal clusters; single egg masses are relatively uncommon. Frogs at Conboy Lake and Trout Lake lay a mix of large and small communal clusters, as well as single egg masses (Hayes et al. 2000, L. Hallock, unpubl. data). At Conboy Lake, single egg masses have made up 33% of the egg laying effort (Hayes et al. 2000). At Trout Lake, the percentage of solitary egg masses that are not associated with communal egg mass clusters varies by year. In 2005 and 2006, 39% of egg mass locations had only one egg mass present, whereas in 2008, 65% of assessed locations had only one egg mass.

Figure 6. Communal egg mass cluster with males in attendance (*Photo by K. Risenhoover*).

Figure 7. Communal cluster with hatchling tadpoles and algae (*Photo by T. Hicks*).

Figure 8. Cloudy appearance of egg masses that have freeze damage and subsequent fungal invasion (*Photo by J. Wieser*).

During development, egg masses typically develop a green tinge from algae that grows within the egg capsules (Fig. 7). Communal egg clusters with recent freeze damage have a rough surface texture where ice shearing has damaged the surface jelly (Leonard 1997). Over time, the dead eggs are invaded by fungal hyphae that degrade the eggs and produce white clouded areas within the communal mass (Fig. 8).

Larvae. The tadpole has an oval body with dorsal eyes, a vent on the right side (dextral vent), a spiracle on the left side (sinistral spiracle) and a dorsal fin that originates on the body near the dorsal tail-body junction (McDiarmid and Altig 1999). An undamaged tail tip is relatively pointed. At hatching, tadpoles are darkly pigmented, have long tails (> 1.5 times body length; Altig 1970) and obvious gills. The ratio of tadpole total length divided by body length will usually be greater than 2.6. They remain associated with the egg mass for a few days (Fig. 7). As the tadpoles grow, the ground color and belly lighten and silver flecks appear. The overall appearance of the belly coloration is creamy white or silver (Nussbaum et al. 1983). Tadpoles can grow to about 110 mm (~ 4 in.) total length before metamorphosis. Newly metamorphosed frogs measure about 33 mm (~ 1.3 in.) SVL (Nussbaum et al. 1983). Smaller sizes have been measured at high elevation sites in Oregon (C. Pearl, pers. comm.).

Habits. Behaviorally, Oregon Spotted Frogs are rarely found away from water (Watson et al. 2003). Basking typically takes place at the water surface within or on top of floating or submerged vegetation. Rarely is this species observed basking on the shoreline (Watson et al. 2000, Hallock and Pearson 2001). The typical stance is a flattened body (dorsally compressed) floating in water or underwater with head held parallel to the sediments. Frogs flee under water when disturbed (Licht 1986a). If already submerged, a frog will conceal itself within muck or loose substrates and remain motionless. If disturbed again, the frog will move a few inches and then lay motionless.

Similar Species

In Washington, three native ranid frogs have ranges that overlap with Oregon Spotted Frogs including Columbia Spotted Frogs, Northern Red-legged Frogs and Cascades Frogs. They are closely related, medium-sized, brownish frogs with dorsal spots (Dunlap 1955, Nussbaum et al. 1983, Jones et al. 2005). A combination of characteristics is needed to distinguish these species (Dunlap 1955, Hayes 1994a).

Columbia Spotted Frog. The Columbia Spotted Frog is found east of the Cascade Crest with a few exceptions near low mountain passes in northern Washington (McAllister 1995). Overlap with Oregon Spotted Frog populations has not been documented (Green et al. 1997). Green et al. (1997) reported that Oregon Spotted Frogs and Columbia Spotted Frogs are morphologically indistinct and must be distinguished by geographic location or genetics; the same is true of the eggs and larvae. Hayes (1994a, 1997a) suggested, however, that differences in ventral pigmentation of adults could be used to distinguish the two species. He found that adult Columbia Spotted Frogs examined from British Columbia, Washington, Oregon and California, lacked coarse dark mottling on the abdomen and had a relatively continuous orange-red or orange pigment wash on the belly and undersurfaces of the upper thighs. If dark mottling was present on the belly, it was limited to a fine peppering of black or gray dots. Extent of these traits varied by population, individual and age of the frog. Hayes (pers. comm.) suggested that Green et al. (1997) examined only specimens in an excited or elevated temperature state (in the lab) and this is why they drew a different conclusion.

Northern Red-legged Frog. Northern Red-legged Frogs are sympatric with Oregon Spotted Frogs at Sumas River, Black Slough, Samish River, Black River and Conboy Lake, and were likely sympatric with historical Oregon Spotted Frog occurrences in the Puget Trough Ecoregion. Direct overlap (co-occurrence) at Conboy National Wildlife Refuge (NWR) is limited to the southwestern corner of the refuge where Northern Red-legged Frogs occur in small numbers (Leonard 1997, M. Hayes, pers. comm.).

The following Northern Red-legged Frog traits differ from Oregon Spotted Frog (Licht 1971b, Nussbaum et al. 1983, Leonard et al. 1993, Hayes 1994a, McAllister and Leonard 1997):

- Adults have a distinct patch of black, greenish-yellow and/or cream-colored mottling in the groin (mainly laterally). The patch is most distinct for frogs that are ≥ 50 mm SVL (Fig. 3).
- Dorsolateral folds are distinct along the entire dorsal margins in adult frogs.
- The eyes are golden brown and oriented outward (laterally) so that only a portion of the pupil is visible when the frog is viewed from above (dorsally) (Fig. 9).

- Foot webbing is greatly reduced between the toes; webbing on the longest toe does not extend past the first (distalmost) and often the second joint and the webbing is concave when the toes are pulled apart.
- Length of the lower leg (fibula-tibia) exceeds half the body length (for frogs 40 mm SVL) and the heel will extend past the nostril if the hind limb is pressed forward against the body.
- The egg mass typically, but not always, is laid below the water surface and attached to a vegetation brace. As the embryos mature, the egg mass may detach from its brace and float to the water surface.
- The ovum averages 3.03 mm in diameter.
- The ratio of tadpole total length divided by body length will usually be less than 2.6.
- The tadpole belly tends to have a pinkish hue.

Figure 9. Pupil orientation and eye color differences between Oregon Spotted Frog (top) and Northern Red-legged Frog (bottom) (*Photo by D. Hagin and L. Hallock*).

In comparison to Oregon Spotted Frogs, transformed Northern Red-legged Frogs are more terrestrial and adults are commonly found away from water bodies in terrestrial habitats during the non-breeding season. In terms of habits, they are more likely to bask on shorelines, flee with strong leaps and shelter at terrestrial sites. The typical stance is with the head raised. The newly hatched tadpoles do not cluster at the egg mass.

No simple traits have been identified that easily and consistently differentiate the tadpoles of Oregon Spotted Frogs and Northern Red-legged Frogs, although a combination of traits can be used. Tadpole identification is complicated by variations in body shape and pigmentation that occur as the tadpole increases in size. Some plasticity is also typical for tadpoles from different areas with different site conditions and predators (Wells 2007).

Cascades Frogs. Cascades Frogs occur in the Olympic and Cascade Mountains typically at elevations above 610 m (2,000 ft.; Jones et al. 2005) but occasionally lower (Corkran and Thoms 1996). This is higher than Oregon Spotted Frogs have been found in Washington except at Trout Lake where co-occurrence is thought to be limited (Hallock 2009). The main occurrence of Oregon Spotted Frogs is found in an extensive emergent wetland at the lower reaches (ca. 579 m [1,900 ft.] elev.) of the watershed (Leonard 1997, L. Hallock, pers. obs.). Cascades Frogs are common in the upper reaches of the watershed at elevations greater than 634 m (2,080 ft.; Hallock 2009). The only exception recorded to date was an adult male Cascades Frog photographed by D. Anderson (pers. comm.) in 2007 at an Oregon Spotted Frog breeding site. This site is at the highest elevation (622 m [2,040 ft.]) known to be occupied by Oregon Spotted Frogs in the Trout Lake Creek watershed. Eggs collected from multiple egg mass clusters and raised to metamorphosis were verified to be Oregon Spotted Frogs and not Cascades Frogs (L. Hallock, pers. obs.).

The following Cascades Frog traits (Fig. 10) differ from Oregon Spotted Frog (Nussbaum et al. 1983, Hayes 1994a, Jones et al. 2005):

- In adults, ventral coloration is white or cream with a yellowish-tan (honey colored) wash on the abdomen and undersides of the legs and no dark mottling on the abdomen. Large females can occasionally have orange coloration, but this appears only as a hint of orange on the yellow background of the undersides of the legs.

- Dorsolateral folds are distinct along the entire dorsal margins.
- Eyes are oriented outward (laterally); only a portion of the pupil is visible when the frog is viewed from above (dorsally).
- Foot webbing is somewhat reduced between the toes and the webbing is concave when the toes are pulled apart.
- Length of the lower leg (fibula-tibia) exceeds half the body length (for frogs > 40 mm SVL) and the heel will extend past the nostril if the hind limb is pressed forward against the body.
- Tadpole coloration is variable but typically dark brown with small dark spots on the dorsal body and tail. The dorsal fin terminates posterior to the spiracle and is relatively low.

Figure 10. Cascades Frog.

In comparison to Oregon Spotted Frogs, Cascades Frogs are more terrestrial in their habits and habitat. They commonly bask on shorelines and grassy edges of water bodies and creeks. The typical stance is with head raised. They flee into water with great leaps and then settle motionless on the substrate. Disturbance will cause them to dart a foot or more to a new location where they lay motionless.

Egg masses of Cascades Frogs and Oregon Spotted Frogs cannot be distinguished visually with certainty, and because the species are known to hybridize, egg masses of hybrids are similar as well.

Hybridization

Amplexed pairs of Northern Red-legged Frog and Oregon Spotted Frog have been observed (Fig. 3, in Thurston County; Licht 1969 in British Columbia). Genetic analysis confirmed that some Black River frogs submitted for testing were *Rana aurora* × *Rana pretiosa* hybrids (K. McAllister and I. Phillipsen, pers. comm.). Hybridization between Oregon Spotted Frogs and Cascades Frogs collected from Gold Lake in the Oregon Cascades was confirmed by Green (1985). The latter hybrids were infertile due to pair failures in meiosis.

GEOGRAPHICAL DISTRIBUTION

The Oregon Spotted Frog is a Pacific Northwest endemic historically distributed from southwestern British Columbia, Canada (Carl 1943, Matsuda et al. 2006) to northeastern California, USA (Fig. 11, Hayes 1997a) in the Puget Trough-Willamette Valley and East Cascades-Modoc Plateau ecoregions (The Nature Conservancy 1999). The northernmost and southernmost documented localities respectively are Morris Valley of the Fraser Valley Lowlands in British Columbia and Pit River System and Lower Klamath Lake in northern California (Hayes 1997a, C. Bishop, pers. comm.). Occurrences are from near sea level to 1,585 m (5,200 ft.; McAllister and Leonard 1997, C. Pearl, pers. comm.). Cushman and Pearl (2007) provide a dot-distribution map of historical and extant occurrences for the entire range.

Figure 11. Known historical range of the Oregon Spotted Frog.

Current occurrences outside of Washington are known from the Fraser Valley Lowlands in British Columbia and the east slope and crest of the Oregon Cascade Range (Pearl and Bury 2000, Cushman and Pearl 2007). Willamette Valley populations in Oregon and all populations in California appear to be extirpated.

In Washington, current occurrences are in the Sumas River, Black Slough, Samish River, upper Black River drainage, lower Trout Lake Creek drainage and at Conboy Lake and Camas Prairie in the Outlet Creek drainage (Fig. 12). All Washington sites, historical and extant, are found below 634 m (2,080 ft.). At the northern extreme of the range, occurrences are probably limited to elevations below 200 m (656 ft.; Pearl and Hayes 2004).

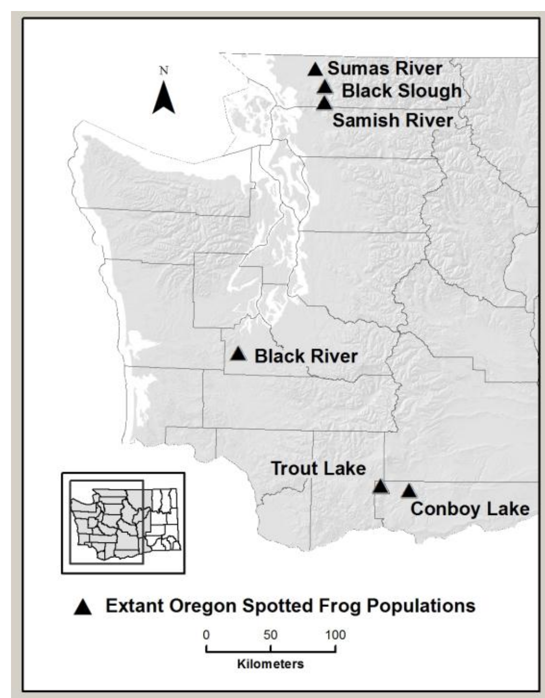

Figure 12. Locations of extant Oregon Spotted Frog populations in Washington.

NATURAL HISTORY

The first extensive investigations of Oregon Spotted Frog life history and population characteristics were those of Licht (1969, 1971a, b, 1974, 1975, 1986a, b) in British Columbia, Canada. The most intensive study of a Washington population took place on Dempsey Creek, a tributary of the Black River, in Thurston County from 1996-2006 at a study site called The Forbes. The study included both mark-and-recapture and radio-telemetry tracking that examined life history, population characteristics, home range, movements and habitat selection (Watson et al. 1998, 2000, 2003, McAllister et al. 2004b, K. McAllister, unpubl. data).

Oregon Spotted Frogs are highly aquatic (Licht 1969, Watson et al. 2003, Hallock and Pearson 2001, Hayes et al. 2001). Of 60 frogs radio-tracked for two years at The Forbes study site on Dempsey Creek, 99% (*n* = 645) of locations were in measureable water (i.e., > 1 cm deep) (Watson et al. 2003).

Oregon Spotted Frogs are occasionally observed out of water. Licht (1969) observed females on land within 18.3 m (60 ft.) of calling males during the breeding season. Newly metamorphosed Oregon Spotted Frogs bask above the water on emergent and floating vegetation (L. Hallock, pers. obs.). Others have noted the occasional observation of Oregon Spotted Frogs on the shoreline (Hallock and Pearson 2001) or 1-2 m from water (Watson et al. 2003, M. Hayes, pers. comm.). Pearl and Hayes (2002) observed adults in Oregon foraging in moist wetland fringes. Observations of frogs even further from water have been made during warm, rainy conditions in Oregon but only in low numbers in comparison to total detections (C. Pearl, pers. comm.).

Reproduction

The following information, unless otherwise cited, is summarized from observations of breeding behavior gleaned over more than a decade of monitoring at three Washington sites: Black River (Watson et al. 1998, 2000, 2003; Risenhoover et al. 2001a; McAllister and White 2001; K. McAllister, pers. comm.; L. Hallock, pers ob.), Conboy Lake (Hayes et al. 2000, 2009) and Trout Lake (Leonard 1997, Lewis et al. 2001, L. Hallock, pers. ob.).

Oregon Spotted Frogs aggregate to breed following the coldest weeks of winter, sometimes corresponding with winter thaw. This occurs in late winter at sites near sea level and in early spring at sites near 579 m (1,900 ft.; Trout Lake and Conboy Lake) elevation. Breeding frogs gather in the seasonally flooded margins and shallows of emergent wetlands in areas that receive minimal shading from the surrounding vegetation. Frogs use the same breeding areas every year and depending on topography and site conditions, may even use the same oviposition site. Licht (1969) reported finding spotted frog eggs within one foot of where frogs laid the previous year. A similar pattern has been observed at The Forbes study site on Dempsey Creek where the frogs breed in the same seasonal pools every year, often using the same oviposition sites. In years of extremely high or low water, the frogs may use alternative sites. At Trout Lake and Conboy Lake, frogs return to traditional breeding areas every year but the oviposition sites change based on water depth at the time of oviposition (Fig. 13). At Conboy Lake, the location of oviposition sites varies by about 15 m year-to-year except in years of extremely high or low water (M. Hayes, pers. comm.).

Breeding activity. Navigation to the breeding site is poorly understood for Oregon Spotted Frogs. Female frogs, studied in British Columbia (Licht1969) and at Dempsey Creek (Risenhoover et al. 2001a) showed a general tendency to move toward breeding areas during the fall as rains inundate the wetlands. The Dempsey Creek mark-and-recapture study revealed that males were present at the traditional breeding areas weeks before breeding commenced and females were also in the vicinity. These findings suggest that non-vocal cues may be used by frogs to navigate to traditional breeding areas in advance of the breeding season (Licht 1969, Duellman and Trueb 1986).

As conditions become suitable for breeding, males start to vocalize. Research by Bowerman (2010) in Oregon using a sub-surface hydrophone, found that some males call from submerged locations tens to hundreds of meters away from the oviposition area several days prior to the formation of breeding aggregations. These vocalizations were not audible at the surface. Male vocalizations also appear to attract females to the egg deposition site (Licht 1969) and once the breeding aggregations form at the oviposition locations, males call only from the oviposition site and calling is restricted to the surface or depths shallow enough for calls to be audible above water (Licht 1969, Briggs1987, Bowerman 2010).

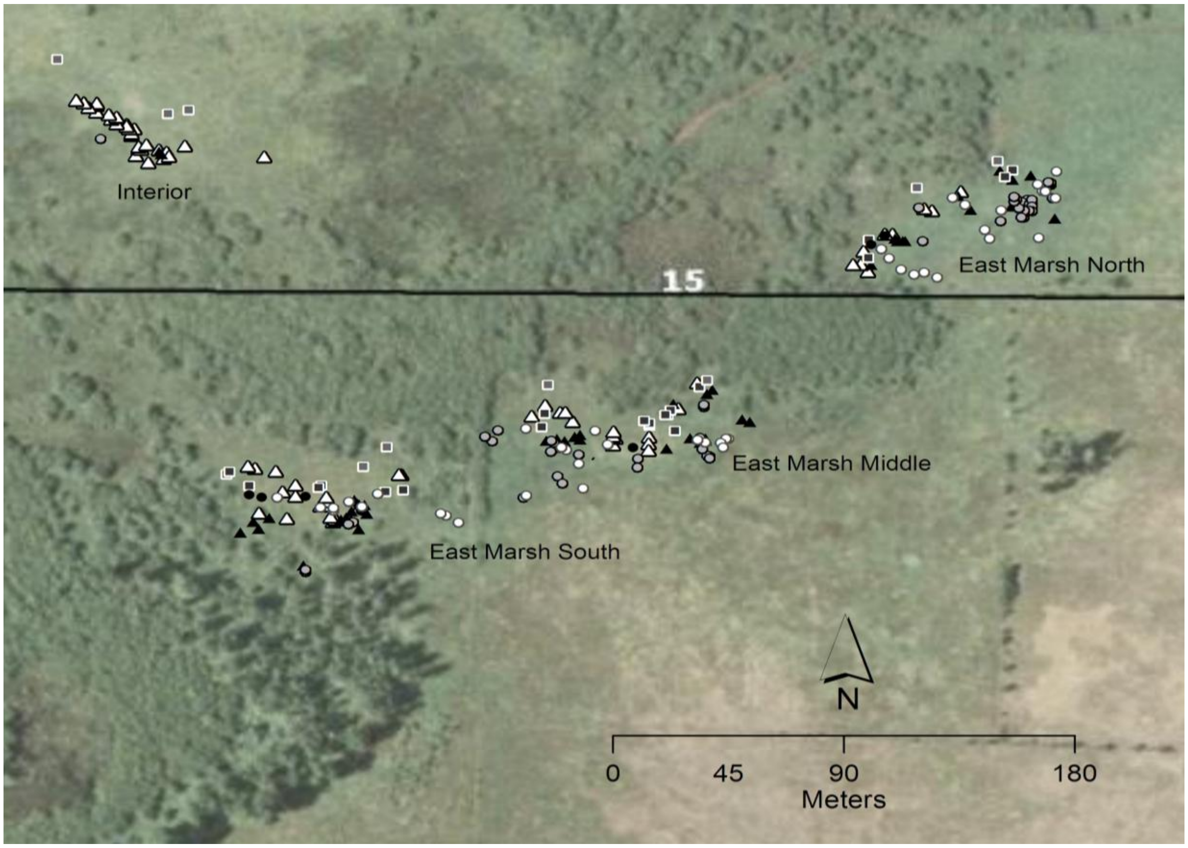

Figure 13. Locations of egg masses at Trout Lake eastern breeding areas 2004-7, 2009-11. Each symbol type represents a different year.

Males at the oviposition sites start to call from shallow water (5–15 cm [2–6 in. deep]) on sunny days when air temperatures reach about 12° C (~ 54° F; Licht 1969). Males congregate in small areas (1–2 m) and exhibit a great deal of activity at the water surface (Licht 1969, Leonard 1997; also observed at Black River sites). Licht (1969) noted that some of this activity is due to males clasping other males. Most calling occurs in daylight and is especially intense on sunny afternoons. Hayes et al. (2000) indicated that most breeding behavior at Conboy Lake was subsurface and frogs were infrequently observed at the surface.

Frogs show some fidelity to the breeding pools. At The Forbes study site on Dempsey Creek, 40% of study frogs were recaptured ≤ 50 m from the breeding pool used in the previous year during the breeding season (Watson et al 2003). One male exhibited exceptional fidelity to a single small breeding pool where he was captured every year from 2001–2005 (K. McAllister, pers. comm.).

Licht (1969) found that females remained apart from males until ready to spawn. Fertilization is external. The male clasps the female around the upper body with his forearms in an embrace called amplexus. This embrace aligns the vents of the male and female in close proximity for spawning. At Dempsey Creek, amplexed pairs have been observed moving up the channel that connects the permanent waters to the seasonal breeding pools (L. Hallock, pers. obs.). Trapping results, for frogs implanted with Passive Integrated Transponders (PIT) and captured in traps during the breeding season at Dempsey Creek, revealed that some pairs (n = 13) remained in amplexus for 7 to 25 days (K. McAllister, pers. comm.).

Oviposition. Initiation dates of egg deposition vary by year depending on spring conditions (Licht 1969). In general, oviposition commences once subsurface waters are 7–9°C (45–48°F) and minimum water temperatures rarely fall below 5°C (41°F) (Licht 1971a, Hayes et al. 2000, McAllister and White 2001). At Oregon sites, water temperatures may exceed 10°C before oviposition is initiated. This suggests that other cues may also be involved (J. Bowerman and C. Pearl, unpubl. data, *cited in* Cushman and Pearl 2007). Oviposition start date has been tracked since 1996 at The Forbes study site on Dempsey Creek (elev. 60 ft. [18 m]). These data reveal a three week time span from mid-February to the first week of March when oviposition commences (Table 1).

Table 1. Initiation of oviposition at Dempsey Creek, Thurston County, Washington 1996-2012.

Start date	Feb 14**	Feb 16	Feb 20	Feb 21	Feb 22	~Feb 26	Feb 27	Mar 3	Mar 5	Mar 6
Years	**2010**	**1998**	**2012**	**1997 2000 2003**	**2002 2004 2005**	**2008**	**2006 2009**	**1996 1999**	**2001**	**2011**

Data from K. McAllister 1996-2006; L. Hallock, 2008-2012; no data from 2007. **Three egg masses were laid by February 9, explosive breeding started February 14, 2010.

Once initiated, breeding is typically "explosive" with many pairs breeding during a short time period (Licht 1969, Nussbaum et al. 1983, Briggs 1987). Most frogs spawn mid-day (Licht 1969). Nocturnal spawning has also been photographed using a remote infrared wildlife camera (J. Tyson & M. Hayes, pers. comm.). Within a breeding area, multiple bursts of egg deposition may occur over a two to three week period.

The first pair of frogs to lay eggs selects the oviposition site. The amplexed pair remains stationary during the extrusion of eggs. At completion, the male swims away and the female remains adjacent to the eggs for a period of time (L. Hallock, pers. obs.). Additional females subsequently deposit their egg masses on top of or immediately adjacent to the initial egg mass. Egg masses are deposited in shallow water typically ≤ 15 cm but up to about 30 cm in depth (Licht 1969, Hayes et al. 2000, Lewis et al. 2001, McAllister and White 2001, Risenhoover et al. 2001a). Pearl et al. (2009b) examined 228 oviposition sites in Oregon and found the mean water depth was 18.5 cm ($s_{\bar{x}}$ = 0.75, median 16.0 cm, range 1–57 cm) Oregon Spotted Frogs will occasionally lay egg masses on floating mats of prostrate reed canarygrass (*Phalaris arundinacea*) in waters that are deeper than typically used (> 30 cm) (McAllister and White 2001, pers. obs. by M. Bailey and others working at Black River sites). Once the communal egg mass is established, males call from near it and on top of it (Fig. 6; Licht 1969). Licht (1969) showed the significance of the egg mass clustering behavior by moving the initial egg mass. All subsequent females laid their eggs on the communal cluster at or near the new location and no females laid at the original location. At Licht's (1974) low elevation study sites, some females bred every year and an average of 643 eggs (range 249–935) were laid in each mass.

Phillipsen et al. (2009) used genetic techniques to study the breeding system of Oregon Spotted Frogs over a year at a pond in central Oregon. Results of their study were consistent with a system in which breeding females laid a single clutch per year, each clutch was fertilized by a single male, and males that bred did so with only one female. Similar work will need to be done at a larger scale to determine if this breeding system is typical of the species range-wide.

Embryo development. The egg laying habits and certain aspects of the globular egg mass shape are adaptations for rapid development. The large egg mass retains more heat than smaller egg masses (Hassinger 1970, Duellman and Trueb 1986) and communal egg deposition produces higher daytime temperatures for the developing embryos (Licht 1971a, Duellman and Trueb 1986, McAllister and White 2001). The clustering of egg masses may also provide the majority of embryos protection from temporary stranding events, freeze damage and egg predators. The placement of egg masses in the comparably warmer shallow waters and the selection of sites that receive minimal shading from the surrounding vegetation also speed development rates. Non-shaded habitat quickly warms on sunny days limiting potential freeze damage from cold nights. Non-shaded habitat also enhances development of algae that live in the eggs and may be critical for oxygen delivery to and removal of nitrogenous waste from the innermost embryos in communal clusters (Pinder and Friet 1994).

Embryo development is highly responsive to small changes in temperature below 20°C (68°F) (Licht 1971a); above this temperature little increase in development rate occurs. Licht (1971a) found that egg masses placed in communal groups in shallow water typically reached 20°C (68°F) daily at his British Columbia study site resulting in maximal growth. He also suggested that by laying mid-day, eggs are immediately exposed to warmer temperatures and undergo several hours of rapid development before being exposed to cold night temperatures. Oregon Spotted Frog embryos examined from his site in lowland British Columbia could tolerate temperatures of 6–28ºC (42.8–82.4ºF; Licht 1971a). Thermal tolerance increases as embryos develop and short-term exposure to temperatures outside this range is survivable. Some variation between populations may also exist as embryos from central Oregon were found to tolerate lower temperatures (Bowerman and Pearl 2010).

Embryo development to hatching can occur in as little as 10 days with 18–30 days being the typical development time (Lewis et al. 2001, McAllister and White 2001, Risenhoover et al. 2001a, Bowerman and Pearl 2010). Toward the end of development, the individual capsules break down. If the communal cluster is in extremely shallow water, the jelly fuses into a single gelatinous mass tinged green with algae. Hatching occurs before the larvae have attained gill circulation (Licht 1971a). Premature hatching may be an adaptation to the lack of well-oxygenated water in warm shallows and the need for larvae to gain direct exposure to water (Licht 1971a). The newly hatched larvae merge together to the center of the communal mass where they start to develop into free-swimming tadpoles. In deeper waters, the communal cluster retains a more globular composition. Free-swimming tadpoles stay associated with the egg mass for several days (Fig. 7).

Larval development. The free-swimming larvae disperse from communal egg mass clusters a week or so after hatching. The tadpoles are primarily herbivorous and this life stage is dedicated to eating and growth. The tadpole stage lasts about four months (Licht 1974).

Metamorphosis, growth and life span. In late summer, the tadpoles metamorphose into fully-formed, small frogs about 33 mm (1.3 in.) SVL (Nussbaum et al. 1983). Growth is rapid until adult sizes are achieved one to two years following metamorphosis (Licht 1975). At the low-elevation Forbes study site, adult males continued to grow an average of 2.2 mm/year and adult females grew 6.2 mm/year (Watson et al. 2000). Longevity greater than nine years was documented for a PIT-tagged Oregon Spotted Frog (K. McAllister, pers. comm.); longevity for most Oregon Spotted Frogs is likely shorter (Licht 1975, McAllister and Leonard 1997).

Sources of Mortality

Oregon Spotted Frog populations suffer mortality mainly from predators and chance environmental events. Most amphibian population studies indicate survival of larvae is low and juvenile (sexually immature frogs) mortality fluctuates more than adult mortality (Duellman and Trueb 1986). Licht (1974) estimated mortality to each Oregon Spotted Frog life stage and predicted only a 1% survival of eggs to metamorphosis, 67% chance of juvenile survival for the first year, and 64% adult annual survival with males suffering more mortality than females (45% versus 67%).

Embryos. Stranding of egg masses is the main threat to developing Oregon Spotted Frog embryos. An entire cohort can be lost in years when water retreats after breeding is underway. Egg mass mortality at Licht’s British Columbia study site would have been 100% in 1969 had he not moved the egg masses

(Licht 1974). Stranding and desiccation mortality at Conboy Lake National Wildlife Refuge in 2000 was estimated to be about 65% (Hayes et al. 2000). At Trout Lake in 2003 losses at the largest breeding area (East Marsh) were at least 61% and may have been as high as 78% (L. Hallock, unpubl. data).

High hatching success has been noted in years with low spring precipitation preceding oviposition followed by rain events after oviposition (Lewis et al. 2001, McAllister and White 2001, K. McAllister pers. comm. at Dempsey Creek). Under these conditions, the frogs were forced to deposit eggs in areas with longer retention of water. The spring rains that followed oviposition maintained suitable water levels for subsequent embryo development and larval dispersal.

Freeze damage is a cause of embryonic mortality in years where temperatures drop below freezing after breeding is underway. Leonard (1997) noted that the layer of freeze damaged eggs in communal clusters exposed above the water line takes on a different consistency from the rest of the mass and he suggested that may afford the surviving embryos some level of protection from subfreezing temperatures. The highest rates of embryo mortality from freezing are observed in years when the egg masses became temporarily stranded due to a period without precipitation that coincides with freezing night temperatures.

In Washington and Oregon, egg predation does not appear to contribute significantly to embryo mortality (McAllister and White 2001, C. Pearl, pers. comm.).

Larvae. Tadpoles are most vulnerable to predation when small (Licht 1974). Significant mortality can also result when tadpoles become isolated in breeding pools away from more permanent waters (Licht 1974, Watson et al. 2003). Watson et al. (2000) reported nearly total reproductive failure in 1998 when the oviposition pools dried due to dry weather following breeding. In addition to being vulnerable to desiccation, tadpoles may succumb to low dissolved oxygen levels in isolated pools and ponds during summer (Watson et al. 2000).

Juvenile frogs. Little is known about survival rates of juvenile Oregon Spotted Frogs; most studies indicate survival of this life stage is typically lower than survival of adult/sexually mature frogs.

Adult frogs. Adult annual survival at the Forbes study site on Dempsey Creek (Black River) was 38% (Watson et al. 2000). Winter mortality of radio-tagged adult females was similar at Trout Lake and Conboy Lake in 2000-2001 (Hallock and Pearson 2001, Hayes et al. 2001). At Trout Lake, five of the 13 study frogs (38%) died after still-water habitats froze: three frogs were predated and two frogs froze or died of anoxia. At Conboy, three of 10 study frogs (30%) died during the overwintering period; two frogs appeared to have been predated and one may have died of anoxia under ice. It should be noted that both winter telemetry studies were conducted during a drought year with some of the lowest winter precipitation levels recorded (Mt. Adams Ranger District weather station, Appendix B). Rainfall from October to March was only 9.3 in. (23.6 cm) compared to average precipitation of 34.9 in. (88.6 cm). These extreme conditions may have been a factor in the high rates of mortality.

Chelgren et al. (2008) examined annual survival of an Oregon Spotted Frog population translocated to created ponds in Dilman Meadows, Oregon. They found that survival was positively related to size and differed seasonally by sex. Annual mortality rate for frogs > 53 mm snout-urostyle length was 32% for females and 43% for males. Mortality was highest for males during and just after the breeding season, whereas mortality for females was highest during summer. The lowest rates of mortality for both sexes occurred in winter. Mortality rates were also found to be higher for translocated individuals during the first year following introduction to the new site.

Predators of Oregon Spotted Frogs. In southwestern British Columbia, Licht (1974) observed invertebrate predators on Oregon Spotted Frog tadpoles at his study site including a giant water bug

(*Lethocerus americanus*), a backswimmer (*Notonecta undulata*), leech (*Batrachobdella picta*), diving beetles (*Dytiscus* spp.), a water scorpion (*Ranatra* sp.) and dragonfly nymphs (Odonata). Licht (1974) studied predation by the backswimmer in the laboratory and found small tadpoles (less 37 mm [~1.5 in] total length) were most vulnerable. He also found leeches consumed eggs and about 75% of metamorphosed Oregon Spotted Frogs had attached leeches. Leech predation on embryos has also been observed at Trout and Conboy lakes (L. Hallock, M. Hayes, pers. obs.), but the slow rate of consumption and the relatively few leeches observed in hatching egg masses make it unlikely that leeches are important predators on embryos (M. Hayes, pers. comm.). However, leeches may be important predators of tadpoles and later life stages because they tend to become more abundant as the season progresses (Berven and Boltz 2001).

To date, no instance of fish predation on Oregon Spotted Frogs has been documented. However, this must be viewed in the context that the life stages most vulnerable to fish predation, young tadpoles, are so rapidly digested that verifying predation via traditional morphological approaches (e.g., dissection) would be unlikely. Effective evaluation of fish predation on tadpoles will require different approaches. Native fish species that occur with Oregon Spotted Frogs at some Washington sites and may prey on their tadpoles include Cutthroat Trout (*Oncorhynchus clarki*), Olympic Mudminnows (*Novumbra hubbsi*) and Three-Spine Sticklebacks (*Gasterosteus aculeatus*) (McAllister and Leonard 1997). Non-native predatory fish are apt to be predators on Oregon Spotted Frogs (Hayes and Jennings 1986, McAllister and Leonard 1997, Hayes 1997a, Pearl 1999). Exotic fish species introduced within the range of the Oregon Spotted Frog include Smallmouth Bass (*Micropterus dolomieu*), Largemouth Bass (*Micropterus salmoides*), Pumpkinseed (*Lepomis gibbosus*), Yellow Perch (*Perca flavescens*), Bluegill (*Lepomis macrochirus*), Brown Bullhead (*Ameiurus nebulosus*), Brook Trout (*Salvelinus fontinalis*), Rainbow Trout (*Oncorhynchus mykiss*) and Fathead Minnow (*Pimephales promelas*) (USFWS 2009).

Licht (1974) found larval and gilled adult Northwestern Salamanders (*Ambystoma gracile*) and larval Rough-skinned Newts (*Taricha granulosa*) to be predators of Oregon Spotted Frog tadpoles in the laboratory. American Bullfrogs (*Lithobates catesbeianus* formerly *Rana catesbeiana*; hereafter "bullfrog") have been documented to consume Oregon Spotted Frogs in both natural and laboratory settings (J. Engler and M. Hayes, pers. comm. as cited in McAllister and Leonard 1997, Pearl et al. 2004, and R. Haycock, video). Many researchers have noted predation on Oregon Spotted Frogs by the Common Garter Snake (*Thamnophis sirtalis*) (Licht 1974, Hayes 1997a, McAllister and Leonard 1997, Forbes and Peterson 1999, Pearl and Hayes 2002, Watson et al. 2003).

Bird species known to prey on Oregon Spotted Frogs include Sandhill Cranes (*Grus canadensis*) (Hayes et al. 2006) and Great Blue Herons (*Ardea herodias*) (Licht 1974). Other potential avian predators include Belted Kingfishers (*Megaceryle alcyon*), Hooded Mergansers (*Lophodytes cucullatus*), Green Herons (*Butorides virescens*), Red-tailed Hawk (*Buteo jamaicencis*), Northern Harrier (*Circus cyaneus*) and Great Horned Owl (*Bubo virginianus*) (Licht 1974, McAllister and Leonard 1997).

Predation by Mink (*Neovison vison*) on Oregon Spotted Frogs was noted in several studies (Bowerman and Flowerree 2000; Watson et al. 2000, Hallock and Pearson 2001). Hayes et al. (2001) indicated that Mink were major wintertime predators of Oregon Spotted Frogs at Conboy Lake. River Otters (*Lontra canadensis*) also prey on Oregon Spotted Frogs at Conboy Lake (Hayes et al. 2005). Licht (1974) observed Red Fox (*Vulpes fulva*), Striped Skunk (*Mephitis mephitis*) and feral Domestic Cat (*Felis domesticus*) at his study site and thought they might also prey on frogs.

Diet

Oregon Spotted Frog tadpoles are primarily herbivorous and feed on algae, decaying vegetation and detritus (Licht 1974). Captive raised tadpoles survive to metamorphosis on a diet of boiled or frozen spinach, leaf lettuce and kale, or a blended vegetable mix of kale, yellow squash and zucchini. Vegetarian diets are supplemented with a protein source of bloodworm cubes, boiled egg white, or commercially available flake fish food or tadpole pellets (Csuti and Sellers 2000; Woodland Park Zoo, Northwest Trek and Oregon Zoo staff, pers. comm.).

Most metamorphosed amphibians are opportunistic predators. Consequently, prey availability and abundance may influence what is ingested and may tend to conceal preferences (Stebbins and Cohen 1995). Licht (1986b) examined the stomach contents from 41 post-metamorphic Oregon Spotted Frogs from British Columbia and found their prey to be invertebrates (Licht 1986b). None of the frogs had empty stomachs. As would be expected, they were opportunistic predators with differences in diet between larger and smaller frogs resulting from limitations in the size of the mouth gape. Prey species were invertebrates found in or near water (also Pearl et al. 2005a). For newly metamorphosed frogs, food items were 85.3% insects (Insecta) and 14.7% spiders (Arachnida). Twenty-five families of insects were represented in the stomachs of the 18 newly metamorphosed frogs examined. Insect families that made up ≥ 10% of food items were Spittlebugs (Cercopidae; 14.7%), Leaf Hoppers (Cicadellidae; 12.9%) and Long Legged Flies (Dolichopdidae; 13.8%). For the 23 larger frogs (juveniles and adults) examined, food items were 92.7% insects (Insecta), 4.7% spiders (Arachnida), and 2.6% mollusks (Mollusca). The diet of the larger frogs was more diverse than the newly metamorphosed frogs with 45 families (versus 25) represented within the 23 stomachs examined. Only two insect groups were represented by ≥ 10% of the total food items: Leaf Beetles (Chrysomelidae; 13.6%) and Ground Beetles (Carabidae; 9.9%). At Conboy Lake, M. Hayes (per. comm.) found adult Diving Beetles (Dytiscidae) made up 50% of food items collected from 86 post-metamorphic Oregon Spotted Frogs that ranged from recently metamorphosed juveniles to large adults. In comparison, Licht's study (1986) found Diving Beetles made up only 1.6 % of food items in all frogs examined (n = 41).

Predation on other frogs and toads has also been reported. In the wild, Licht (1986b) observed Oregon Spotted Frogs grab and swallow newly metamorphosed Northern Red-legged Frogs. In captivity, adult Oregon Spotted Frogs consumed adult Pacific Treefrogs (*Pseudacris regilla*), juvenile Northern Red-legged Frogs and juvenile Oregon Spotted Frogs. Adults have also been observed consuming juvenile Western Toads (*Bufo* [*Anaxyrus*] *boreas*) in Oregon (Pearl and Hayes 2002). Juvenile Oregon Spotted Frogs captured in conspecific communal egg mass clusters were found to have consumed the hatching Oregon Spotted Frog larvae (K. McAllister, per. comm.).

Activity Patterns, Home Range, Seasonal Movements and Dispersal

Watson et al. (1998, 2000, 2003) examined home ranges and movements of telemetered Oregon Spotted Frogs over multiple seasons and years at Dempsey Creek in the Black River watershed. Attempts were made to locate telemetered frogs twice each week (result was $\bar{x}$ = 4 days, SE = 1). Home range size was different among seasons as was the rate of movement. Home ranges and movement rates in the breeding and wet season were two to four times greater than in the dry season. The two types of annual movement patterns were frequent long-distance movements between widely spaced locations and infrequent movements between pools in close proximity. After breeding, study frogs made distinct down-drainage movements away from the seasonally flooded wetland margins; they distributed themselves throughout the study area resulting in occupation of 60% to 65% of the area that encompassed all telemetered frog locations throughout the year. During the summer dry season, frogs had the smallest home ranges and were primarily limited to remnant pools.

The population range for 60 frogs monitored by Watson et al. (1998, 2000, 2003) from February 1997 to January 1999 was approximately 30 ha [75 ac] (n = 654 locations; 100% fixed kernel [FK] = 68.8 ac.; 100% minimum convex polygon [MCP]). No individual frog was monitored for an entire year. The best estimate of the mean home range for four frogs monitored most of the year was 2.2 ha (5.4 ac) (100%

FK). The breeding range of the population for 42 frogs monitored February to May overlapped 49% of the population range (FK =13.8 ha; MCP =18.8 ha; *n* = 292 locations). The dry season range of 18 frogs monitored from June to August overlapped 45% of the population range (FK =12.4 ha; MCP = 21.7 ha; *n* = 157 locations). The wet season range for 21 frogs monitored from September to January overlapped 60% of the population range (FK = 16.7 ha, MCP = 19.0 ha; *n* =157 locations).

The study frogs moved an average minimum of 5 m/day (16.4 ft. /day; SE = 1) throughout the year. The female frog with the largest home range (5.0 ha [12.3 ac.]) moved at a rate (6.8 m/day [22.3 ft. /day]) similar to another female (6.6 m/day [21.6ft. /day]) whose home range was four times smaller (1.3 ha [3.2ac.]). Frogs exhibited exceptional rates of movement during the breeding season; seven frogs (six females, one male) moved at a rate of 32–111 m/day (105–364 ft. /day) for 2–18 days.

Tracked individuals used the same areas in different years indicating site fidelity. Fidelity to seasonal pools (frogs recaptured ≤ 50 m [164 ft.] from same location the previous year) was 40% between breeding seasons (*n* = 14 frogs), 57% in the dry season (*n* = 4 frogs) and 57% for the wet season (*n* = 4 frogs).

Oregon Spotted Frogs occasionally move long distances. McAllister and Walker (2003) recaptured three frogs (an adult male and two adult females) originally captured in a pasture on upper Dempsey Creek that had moved to the Black River, a creek distance estimated to be 2,360 m (7,750 ft.). Forbes and Peterson (1999; Oregon) found two toe-clipped metamorphosed frogs, originally captured within one meter of each other in August 1997, moved downstream a distance of 1,245 m (4,083 ft.) and 1,375 m (4,510 ft.), respectively, by August 1998. An adult female PIT tagged (Passive Integrated Transponder) in August 1998 was captured in August 1999 having moved a stream distance of 2,799 m (9,183 ft.; straight-line distance of 2,530 m [8,300 ft.]). She moved through 1.6 km (1 mi.) of creek with little typical spotted frog habitat. Forbes and Peterson (1999) indicate that these movements were atypical of the rest of the marked frogs (*n* = 6) that when recaptured a year later had moved 10 to 210 m (32.8–689 ft.). Frogs marked in 1997 and recaptured in 1999 (*n* = 5) moved estimated distances that ranged from 47 to 366 meters (154–1,200 ft.).

Winter. Information about overwintering behavior and movements come from four Washington studies (Hayes et al. 2001 at Conboy Lake; Hallock and Pearson 2001 at Trout Lake; Risenhoover et al. 2001b and Watson et al. 2003 at Black River) and a study in Oregon (Shovlain 2005 at Jack Creek). The studies took place in two different ecoregions with different climates. The Black River population complex occurs in the Puget Trough Ecoregion where the maritime climate has mild summer and winter temperatures. Subfreezing conditions occur for short periods in November-March but ice rarely persists for more than a week. Day temperatures are usually above freezing and warm enough to melt thin ice that may form during cold nights (Risenhoover et al. 2001b). Trout Lake, Conboy Lake and Jack Creek occur in the East Cascades-Modoc Plateau Ecoregion where the climate is more continental. Winters are cold enough to produce ice-capped water bodies from December to February. Temperatures regularly extend below freezing between mid-October and early March and winter precipitation falls as snow.

Frogs in the Washington overwintering studies (*n* = 34) were mostly female. Study frogs remained active throughout most of the winter with no prolonged period of hibernation. Observed periods of inactivity were short in duration (< 1 month) (Hallock and Pearson 2001, Risenhoover et al. 2001b, Watson et al. 2003). Frogs in both ecoregions were observed active under ice (Leonard et al. 1997a, Hallock and Pearson 2001). The study frogs at Trout Lake were active despite water temperatures at frog locations that measured 0.2–2°C (32.4–35.6°F). The activity of three frogs included movements of greater than 50 m (164 ft.) during the mid-December to early January period; one study frog's movements from December 19-January 9 totaled 307 m (1,007 ft.) based on weekly moves of 43 m, 164 m and 100 m (141, 538 and 328 ft.). One frog was immobile when removed from a flooded tunnel in a creek bank January 9; the frog was able to right itself within 15–30 seconds and swam away when released a few minutes after capture

(Hallock and Pearson 2001). Three Black River study frogs were buried at the base of dense vegetation in shallow water under ice (depth 17.4± 0.8 cm) from mid-December until January (Watson et al. 2003).

Overall mean distance moved per day (straight-line) was similar for the Black River study frogs (mean = 6.7 m/day, range 2.2–11.6 m) and Trout Lake study frogs (mean = 6.0 m/day, range 1.9–12.3 m) whereas Conboy Lake study frogs had shorter mean distance movements per day (mean =1.7 m/day, range 0–20 m/day). Hallock and Pearson (2001) noted that radio-tracked frogs did not move much more than 400 meters (1,312 ft.) from their initial capture point during the fall and early winter study period. The Black River and Trout Lake studies had a mix of active and sedentary individuals, as did the Jack Creek, Oregon site. Also some individuals moved initially and then settled into a sedentary mode. Movement distances at Conboy Lake (Hayes et al. 2001) were variable and were significantly different among pre-ice, ice and post-ice intervals.

Hallock and Pearson (2001) suggested the differences in movements and activity of individuals might have been related to the habitat type where frogs were initially captured. Frogs captured in still-water habitat may have been compelled to disperse as these habitats were capped by ice and snow resulting in declining oxygen levels, whereas frogs originally captured in the creek were not impacted by either freezing waters or declining dissolved oxygen levels. Risenhoover et al. (2001b) reported a similar mix of active and sedentary study frogs at their lowland Puget Sound site where neither ice capped water bodies nor low dissolved oxygen levels occurred.

Interspecific Interactions among Native Ranids

Licht (1969; 1971a, b; 1974; 1986a, b) examined the behavior differences between co-occurring populations of Northern Red-legged Frogs and Oregon Spotted Frogs in British Columbia, Canada. Licht (1986b) noted differences in diet that he attributed primarily to differences in behavior and habitat use. Northern Red-legged Frogs were more terrestrial and typically hunted from terrestrial sites whereas Oregon Spotted Frogs were aquatic. While both species primarily consumed invertebrates, Northern Red-legged Frog diets had more terrestrial invertebrate species. He also found that while both species bred within close proximity, reproductive isolation was maintained by pre-breeding and breeding behavior differences (Licht 1971a). Northern Red-legged Frogs differed in vocalizing away from the shoreline, underwater, and typically males were separate from each other. Most calling was nocturnal as opposed to Oregon Spotted Frogs that called primarily during the day. Northern Red-legged Frog females differed in spawning at night, depositing their egg mass in deeper water (> 30 cm), attaching the egg mass to a brace and laying it separate from other egg masses. Some habitat overlap did occur between the two species. This may provide opportunity for the occasional hybridization that has been observed.

Briggs (1987) described breeding and egg deposition behavior of Cascades Frogs at a site in Jefferson County, Oregon. These behaviors were similar to those in Oregon Spotted Frogs but the advertisement call differed. The male advertisement calls of both species included a similar series of clucks and double-clucks but Cascades Frogs had a more varied repertoire and the “mew” call was distinctive in being much longer and broader.

Environmental Health, Medical Applications and Ecological Importance

Oregon Spotted Frogs serve an important role as biological indicators of environmental health, may provide benefits to human health through new medical applications and are ecologically important. The following summarize some of these benefits.

Biological indicators of environmental health. Frogs are sensitive to pollutants and other environmental changes and this can make them important biological indicators of environmental health (Linder et al. 2010). This sensitivity is primarily due to their "biphasic life cycle" and permeable skin and eggs (Duelman and Trueb 1986). The biphasic life cycle refers to the two forms most frogs take during their lives: an herbivorous, filter-feeding, non-reproductive, aquatic larva and a carnivorous, predatory, reproducing, terrestrial frog. The larva, or tadpole, is adapted for aquatic life and rapid growth by consuming algae and decaying plant matter. The metamorphosed frog, on the other hand, has a body that is primarily adapted for jumping and capturing insect prey. Each phase is independent, has evolved different adaptations, lives in different environments and has different responses to changes in the environment (Harris 1999). The tadpole has considerable developmental plasticity and specialized traits not retained by the adult. Metamorphosis is abrupt and dramatic with major biochemical and morphological alterations (Duellman and Trueb 1986). Such extreme re-organization presents an additional opportunity for developmental abnormalities if pollutants are present in the environment.

Frogs also differ from other vertebrates in the way they are exposed to water and soil and this provides an opportunity for direct exposure to soil and waterborne pollutants. The frog egg is protected only by a gelatinous coat that is filled with water directly from the environment. The tadpole is aquatic, has highly permeable skin and filters large amounts of water while feeding on algae. Tadpoles may also feed on sediments (detritus) and/or shelter and rest on them. The metamorphosed frog has skin that differs from other vertebrates in lacking scales, feathers or hair. Because of this, a frog is in direct contact with soil and other substrates. The skin is also highly permeable and plays many roles in daily survival. Under certain circumstances it functions as the main respiratory organ and to function as such, it must be kept moist. Frogs do not drink water; instead water is absorbed through the skin by direct contact with damp soil or water.

Potential medical and agricultural applications. Chemical prospecting for potential medical application is underway especially to combat microbes that are drug resistant (Clarke 2007). Amphibian skin is one of the richest sources of antimicrobial peptides (Rinaldi 2002). This may be a consequence of amphibians being exposed to a variety of microbial and fungal pathogens in soil and other moist environments. More than 200 such peptides have been isolated from diverse frog families since the late 1980s (Conlon 2004). Uccelletti et al. (2010) suggest that frog antimicrobial peptides may protect against life-threatening, multidrug-resistant infections such as *Pseudomonas aeruginosa*, an opportunistic pathogen that causes some of the most prevalent life-threatening infections in humans (e.g., lung infections in cystic fibrosis patients). Conlon (2004) found that by making selective changes to frog's naturally occurring peptides, analogues could be developed that show increased potency against microorganisms but reduced toxicity toward mammalian cells. Research is also being done using frog antimicrobial peptides to increase plant pathogen resistance (Ponti et al. 2003).

Preserving Oregon Spotted Frogs may one day prove important for these types of medical advances. Tennessen et al. (2009) found the pattern of expressed antimicrobial skin peptides from Northern Leopard Frogs (*Lithobates [=Rana] pipiens*) were distinct for three geographically separate populations and found four peptides not previously known. They interpreted these differences as evidence that variation in peptide expression may be related to current and past encounters with skin microbes. Skin peptides in Oregon Spotted Frog have only recently been examined including research on the evolutionary history of Pacific Northwest ranids and chytrid fungal disease resistance (Conlon et al. 2007, Conlon et al. 2011). Conlon et al. (2011) found that Oregon Spotted Frogs possess more antifungal and antibacterial skin peptides than any other western North American ranid frog. The research on leopard frogs suggests the possibility that each geographically isolated Oregon Spotted Frog population may have antimicrobial peptides that are unique.

Ecological Importance. The ecological importance of frogs is frequently underestimated. In part, this is because the role of the frog (larval and metamorphosed) has not been explored sufficiently (McDiarmid and Altig 1999). What is known is that frogs are highly efficient at biomass conversion (Pough 1980) and play a significant role in: 1) transferring nutrients between freshwater and terrestrial ecosystems; 2) control of insect populations; and 3) providing food for diverse aquatic and terrestrial predators (Marcot and Vander Heyden 2001). As an example of the impact metamorphosed frogs have on insect populations, Johnson and Christiansen (1976) estimated that a small pond population of 1,000 Northern Cricket Frogs (*Acris crepitans*; a tiny frog ≤3.8 cm [1 ½ in.]; Conant 1986) would consume approximately 4.8 million small arthropods, primarily insects, per year. Tadpoles are freshwater "ecosystem engineers," that influence primary productivity and algal assemblages (Seale 1980, Pryor 2003, Mohneke and Rödel 2009). Tadpoles, specialized for feeding and growth, are efficient at extracting a wide variety of particle sizes from water (Alford 1999), can ingest all unicellular primary producers and are among the largest free-swimming freshwater organism able to subsist on planktonic primary production (Wassersug 1975). The tadpoles of most frog species increase mass by factors of 50 or more before metamorphosis (McDiarmid and Altig 1999). They often develop in transient aquatic environments where they are able to exploit rich resources (Wassersug 1975). For instance, Oregon Spotted Frogs exploit the productivity of seasonally wet meadows by laying their eggs in this habitat type. As a result, tens- to hundreds of thousands of Oregon Spotted Frog tadpoles consume algae and decaying matter in these seasonally wet shallows before moving to more permanent waters.

HABITAT REQUIREMENTS

Oregon Spotted Frogs are generally associated with wetland complexes > 4 ha (10 acres) in size with extensive emergent marsh coverage that warms substantially from spring to fall (Pearl and Hayes 2004). Hayes (1994a, b) stressed the reliance of this species on warm-water habitats. The benefit of larger sites may be of indirect nature, primarily providing a diversity of habitat types. Large sites may also be required to support populations large enough to offset the suspected high adult population turn-over rates (M. Hayes, pers. comm.). Several occupied sites in Oregon are at or below the 4 ha size but these are thought to have functioned within a larger group of interacting habitats historically (Pearl and Hayes 2004). Wetland complexes with diverse hydrological regimes may also be favored such that seasonally inundated habitats are adjacent to more permanent waters.

Washington's remaining populations of Oregon Spotted Frogs occupy palustrine wetlands connected to riverine systems. The perennial creeks and associated network of intermittent tributaries provide aquatic connectivity between breeding sites, active season habitat and overwintering habitat. Additionally, perennially flowing waters may provide the only suitable habitat during extreme summer drought or during winter when still-waters become hypoxic (low dissolved oxygen levels that are detrimental to aerobic organisms). Associated wetlands have a mix of dominance types including aquatic bed, emergent, scrub-shrub, and forested wetlands. The seasonally inundated wetland margins are frequently hay fields and pasture. The less disturbed sites have wet meadows and prairie uplands. Some occupied sites are engineered by American Beaver (*Castor canadensis*, hereafter "beaver"). All the remaining Oregon Spotted Frog sites have moderate to severe habitat alteration including a history of cattle grazing and/or hay production as well as encroaching or established rural residential development. Hydrology has been altered to some extent at all sites with the most extensive changes at Conboy Lake National Wildlife Refuge and surrounding area.

Watson et al. (2000; Black River) found that different life stages of Oregon Spotted Frogs had different hydrological needs that varied by season. For development of eggs and larvae, relatively stable water levels were needed during the breeding season. For survival of transformed frogs, deeper water pools were critical during the summer dry season. Adequate water levels over emergent vegetation were important for survival of all age classes during the wet season and coldest time of the year. A topographic gradient with overall gradual relief was vital for providing this mix of aquatic conditions and aquatic connectivity between areas used. Watson et al. (2003) also found that habitat needs varied by season. In general, frogs selected sedge-dominated and hardhack (*Spiraea douglasii*)–dominated types and avoided reed canarygrass types, alder/willow, and deep water. Uplands were not used. During the breeding season, frogs preferred sedge-dominated habitat particularly sedge/rush found in association with breeding sites. During the dry season, frogs preferred hardhack-dominated habitats. The hardhack was in the deepest waters and these retained water during dry periods. Also, the hardhack shaded out reed canarygrass preventing dense, impenetrable grass cover. Aquatic connectivity was essential; frogs did not move terrestrially to isolated ponds.

Reed canarygrass, an invasive species, is a common component of wetland vegetation in Washington. At The Forbes site on Dempsey Creek, reed canary grass made up 38% of the vegetation in the late 1990s (Watson et al. 2000). Watson et al. (2000) found that while reed canarygrass was used by telemetered study frogs with moderate frequency (30%; 90% confidence intervals 25–34%), it was actually avoided by the frogs overall. Oregon Spotted Frog use was conditional depending on degree of cattle grazing. Cattle grazing created open areas in otherwise too dense habitat.

Watson et al. (2003) stressed that the most important features for microhabitat use were water depth, flow characteristics (still water was used over flowing water) and a high degree of water surface exposure (i.e., 50–75% water) or conversely, a low to moderate degree of emergent vegetation (i.e., 25–50%). The predominant use of shallow water habitat by Oregon Spotted Frogs was illustrated by Watson et al. (1998, 2003), who found Oregon Spotted Frogs (n = 295 radio-telemetry locations) selected water depths of 10–30 cm (~4–11.7 in.) with less emergent vegetation and more submergent vegetation than adjacent habitats.

Breeding. Oregon Spotted Frogs select breeding sites in seasonally flooded wetland margins adjacent and connected to perennial wetlands (Fig. 14; Licht 1971a, Hayes et al. 2000, Pearl and Bury 2000, Watson et al. 2000, Lewis et al. 2001, McAllister and White 2001, Risenhoover et al. 2001a, Watson et al. 2003, Pearl and Hayes 2004). Full solar exposure also seems to be a significant factor in breeding habitat selection (McAllister and White 2001, Pearl and Hayes 2004). Oviposition sites are in shallow waters typically around 15 cm (6 in.) deep when initially laid, with low vegetation structure that does not shade the eggs. Typically these locations are near shore but can also be in areas with extensive mid-wetland shallows. Low vegetation structure is typical of early successional vegetation stages but can also result from cattle grazing, haying, and mowing. Heavy snow pack can also flatten emergent vegetation providing suitable oviposition conditions.

Figure 14. Typical breeding habitat in seasonally flooded wetland margins.

Suitability of reed canarygrass-dominated areas for oviposition habitat is related to the density and form of grass at the time of oviposition. Dense monocultural stands with thick thatch and a tall vertical structure in the spring are unsuitable. Almost all other stand variations may provide suitable oviposition habitat given that reed canarygrass is prostrate at the time of oviposition or that sunny openings are present within the reed canarygrass-dominated areas. These openings can be natural or due to disturbance (Watson et al. 2000, McAllister and White 2001). Oregon Spotted Frogs have also laid egg masses on floating mats of prostrate reed canarygass at Black River breeding sites (*for instance*, McAllister and White 2001). These floating mats provide microhabitat conditions similar to the shallow water sites typically selected during oviposition.

In a few places, Oregon Spotted Frogs egg masses have been found under trees and shrubs including dormant Oregon white oaks at Beaver Creek, a tributary of the Black River (Watson et al. 2000) and dormant red alders (*Alnus rubra*; L. Hallock, pers. obs.) at Trout Lake. Along the Black River ("Pipeline site"), egg masses have been found in shallow water openings within swampy areas dominated by alders (*Alnus* spp.), hardhack (*Spiraea* sp.) and other shrubby species (Fig. 15).

Post-breeding. Post-breeding habitat use is the least studied of Oregon Spotted Frog habitat associations in Washington. During the summer drought (July to September), Dempsey Creek study frogs in the Black River watershed were restricted to remnant pools that persisted during this time (Watson et al. 2003). At the Jack Creek site in Oregon, habitat use was primarily near-stream with frogs showing high micro-site fidelity (Shovlain 2005).

Figure 15. Atypical breeding habitat in swampy area adjacent to the Black River (Pipeline site), Thurston County.

Winter. During the coldest months of the year, Oregon Spotted Frogs require well-oxygenated waters (Hallock and Pearson 2001, Hayes et al. 2001, Tattersall and Ultsch 2008) and sheltering locations protected from predators and freezing conditions (Risenhoover et al. 2001b, Watson et al. 2003). This is especially important during the coldest periods when activity of ectotherms, including frogs, is expected to be the lowest. The use of different types of overwintering locations will influence mortality (Tattersall and Ultsch 2008). Frogs that overwinter in still-water risk freezing and severe hypoxia or anoxia. Flowing systems, such as creeks and springs, maintain higher oxygen concentrations and are less likely to freeze but frogs are at risk from scouring events after heavy rains (Bull and Hayes 2001, Tattersall and Ultsch 2008).

The Washington populations in Klickitat County and the Oregon populations (all in the East Cascade-Modoc Plateau Ecoregion), are in water bodies that often become capped by ice and snow during winter. When this condition persists for weeks, hypoxic water conditions occur due to cessation of photosynthesis combined with oxygen consumption by decomposers (Wetzel 1983). Lethal oxygen levels for Oregon Spotted Frogs have not been evaluated; most fish cannot tolerate levels below 2.0 mg/L (Wetzel 1983). Oregon Spotted Frogs can tolerate levels at or somewhat below 2.0 mg/L, at least for short periods (Hayes et al. 2001). During the interval of cap ice at Conboy Lake in 2001, mean dissolved oxygen levels at locations where Oregon Spotted Frogs that survived the winter were found were 1.6 mg/L (2.5 mg/L SD). In general, frogs can also survive short periods (a matter of days) within anoxic mud (Tattersall and Ultsch 2008). In laboratory experiments, frogs (*Rana temporaria*) could detect isothermal variations in dissolved oxygen and spent 70% of their time at oxygen levels that allowed aerobic metabolism (Boutilier et al. 1999). Other ranid species have been found to use overwintering microhabitats with well-oxygenated waters (Ultsch et al. 2000, Lamoureux and Madison 1999). In a northeastern Oregon field experiment, Columbia Spotted Frogs selected areas with significantly higher dissolved oxygen concentrations compared with fixed sample locations (Bull and Hayes 2001).

At Trout Lake and Conboy Lake, Oregon Spotted Frogs originally captured in still-water habitats moved to creeks and canals during the coldest months after the still-water habitats had been ice and snow capped for about a month. One Trout Lake study frog moved to an area of ground water discharge that was ice-free. Shovlain (2005) also reported use of active springs by study frogs during winter at her Oregon study site (mid-November, $n = 6$). Rombough and Pearl (2005) provide a short note regarding discovery of an aggregation of nine adult Oregon Spotted Frog males under a boulder near a Penn Lake inlet (Oregon; elev. 1,445 m/4,741 ft.) in early September. Hallock and Pearson (2001) and Hayes et al. (2001) concluded independently that dissolved oxygen levels were the best explanation for observed movements of study frogs from still-water to flowing habitats at Trout Lake and Conboy Lake in 2000-2001. Waters freezing to the sediments was rejected as the cause because deeper areas of the still-water habitats had unfrozen waters under the ice.

The significance of beaver impoundments. Beaver impoundments and engineering are beneficial to Oregon Spotted Frog populations. The resulting pond is a water storage reservoir that raises the water table, reduces downstream erosion, lessens flood events (unless the dam is breached), holds water year round, and maintains stream flow during dry periods. If the beaver dam is not breached, silt will fill the pond over time resulting in meadow habitat (Feldhamer et al. 2003, Rosell et al. 2005). The stream will continue to flow through the meadow and will flood the meadow during high flows. Beaver meadows are fertile due to the nutrients trapped and transported into the system from the terrestrial habitat (Feldhamer et al. 2003). Grasses and sedges (graminoids) typically dominate these meadows. In northern forest, beaver meadows persist as graminoid meadows for many decades after beaver abandon a site (Feldhamer et al. 2003, Rosell et al. 2005). Speculation is that conifer trees cannot quickly colonize these sites without the obligate ectomycorrhizal fungi associated with their roots. Potential species vectors such as the Red-backed Vole (*Myodes* sp.) generally avoid beaver meadows, so colonization by conifers is delayed (Feldhamer et al. 2003). These sites also have the potential of re-colonization by beaver after many decades of absence. The resulting changes increase the complexity of the ecosystem (heterogeneity) and result in a shifting mosaic of habitat types, including vegetation in early seral stage, that vary spatially and temporally as beaver abandon old sites, colonize new sites or return to previously occupied sites (Feldhamer et al. 2003).

This complex mosaic of aquatic habitat types meets the seasonal habitat needs of the Oregon Spotted Frog. Specifically, the silt-filled abandoned ponds become shallow wetlands and beaver meadows that have characteristics ideal for oviposition. Beaver-maintained ponds retain deeper waters important for summer foraging and growth of metamorphosed Oregon Spotted Frogs. These ponds also provide overwintering habitat. When hypoxic conditions occur in the wetlands and ponds, the frogs can move to the more oxygenated waters of the associated creek. Oregon Spotted Frogs in creeks use microhabitat features created by beaver activity such as deposited large woody debris and bank tunnels (Hallock and Pearson 2001, Shovlain 2005). Springs, another habitat feature noted as potentially significant for overwintering Oregon Spotted Frogs (Hallock and Pearson 2001, Shovlain 2005), can result from beaver impoundments. Silt accumulation and production of organic soils from vegetation decomposition within impoundments may also be significant for Oregon Spotted Frogs. Two studies in Washington found Oregon Spotted Frogs used organic soils more than mineral soils (Hallock and Pearson 2001, Risenhoover et al. 2001b). Oregon Spotted Frogs typically dive into the bottom sediments to escape predators; organic mucks provide better cover than mineral soils. Lastly, the warmer waters and higher aquatic invertebrate production (Feldhamer et al. 2003) benefit Oregon Spotted Frogs. Beaver are present at the remnant populations in Washington but their role as ecological engineers is curtailed within populated areas because they destroy trees that are valued by landowners and flood roads and property.

WASHINGTON POPULATION STATUS

Historical Distribution

Locations of Oregon Spotted Frog populations in Washington went largely undocumented historically. McAllister and Leonard (1997) reviewed museum records from major herpetological collections of North America to assess historical distribution of Oregon Spotted Frogs in Washington. Examination of museum specimens confirmed Oregon Spotted Frogs were present in nine widely separate areas of Washington: Concrete, Sedro Woolley, Mount Vernon, Monroe, Seattle, Kapowsin, Spanaway, Vancouver and Trout Lake (Table 2; McAllister and Leonard 1990, 1991, McAllister et al. 1993). McAllister and Leonard (1997) identified two additional historical localities, Pattison Lake and Kent, based on reports by credible observers (James Slater and Warren Jones). McAllister and Leonard (1997) also used written accounts to provide corroboration for occurrences (Dickerson 1906, Slipp 1940, Wright and Wright 1949, Slater 1955, Nussbaum et al. 1983; and pers. comm. from J. Slipp, J. Knudsen and E. Nelson).

Based on information compiled by McAllister and Leonard (1997), Oregon Spotted Frogs in Washington occupied at least twelve drainages including two drainages not identified until the 1990s: Skagit River drainage near Mt. Vernon, Sedro Woolley and Concrete; the floodplain at the confluence of the Skykomish-Snoqualmie rivers near Monroe; the Green River drainage at Kent; Lake Washington at Seattle; Spanaway Creek drainage at Spanaway, Spanaway Pond, and Little Spanaway Lake; South Creek three miles west of Kapowsin; Patterson (Pattison) Lake within the Henderson drainage; the upper Black River drainage; Burnt Bridge Creek drainage at Orchards; Trout Lake Creek at Gular and Trout Lake; and Outlet Creek at Conboy Lake and Camas Prairie (Fig. 16). Plat maps from the late 1880s indicate that the Vancouver area was well populated beyond the city center. The Burnt Bridge Creek drainage is closest to the city center but it is possible that the Oregon Spotted Frog specimen collected in 1909 was from one of the other nearby drainages (e.g., Salmon Creek watershed) with Vancouver attributed as the closest major landmark. An Oregon Spotted Frog was reportedly collected near Brush Prairie in 1968 but the specimen was lost (McAllister and Leonard 1991, 1997). Brush Prairie would be in Salmon Creek drainage.

In 2011-2012, Oregon Spotted Frogs were found near the town of Nooksack in an unnamed tributary of the Sumas River; in the Black Slough, a tributary of the South Fork Nooksack River, and in the Samish River south of Acme (Bohannon et al. 2012). Assuming that watersheds currently occupied were also occupied historically, Oregon Spotted Frogs occupied at least fifteen creek and river drainages in Washington.

Table 2. Oregon Spotted Frog localities in Washington based on museum records

Location	County	Date	Source[1]
"Puget Sound"	Unknown	Pre-1853	USNM498959, 498960, 11409, 5975, 9421, 9467, 131512, 310765
Vancouver	Clark	30 Sept 1909	USNM45866, 45867
Orchards	Clark	15 March 1962	PSM9614 (Specimen lost)
Seattle (includes Lake Washington)	King	1905	USNM35638, 35639; AMNH 34, 35.
Trout Lake, 0.5 mi. North	Klickitat	25 June 1958	WSU75-1127
Trout Lake, 0.5 mi. Northeast	Klickitat	25 June 1958	WSU58-378
Trout Lake, 1 mi. North	Klickitat	25 June 1958	WSU58-369, 58-370
Trout Lake	Klickitat	30 August 1918 2 Sept 1938 2 Sept 1947 11 Sept 1947 21 August 1950 22 August 1950 2 Sept 1947 21 August 1992	USNM61473, 61474 MVZ41432 PSM5596 -5602 PSM5607 PSM 7371, 7372 PSM7386, 7387, 7388; FLM3333 UOK30236 RM1008
Trout Lake Creek, Guler	Klickitat	2 Sept 1938	MVZ41433
Conboy Lake National Wildlife Refuge	Klickitat	21 August 1992	RM1004-1007, 1019, 1020
Spanaway Lake pond	Pierce	Unknown 2 August 1937 10 August 1937 7 June 1938 23 August 1939 24 February 1959	CAS7295 PSM2100 PSM2071 PSM2712, 2713 USNM312413, 312414 PLUA40-43
Kapowsin, 3 mi., West	Pierce	10 August 1937	PSM2069
Mount Vernon, 3 mi. West	Skagit	9 October 1937	PSM2134-2137
Sedro Woolley, 3 mi. East	Skagit	23 August 1930	PSM1444, 1446
Concrete, 2 mi. Northwest	Skagit	23 April 1930	PSM1441
Monroe, 3 mi. South	Snohomish	7 Sept 1939	PSM2667
Dempsey Creek floodplain	Thurston	24 October 1990 18 May 1994	UWBM2217 (photo voucher) RM1001-1003

[1] Museum acronyms as follows: AMNH-American Museum of Natural History, New York; CAS-California Academy of Sciences; FLM-Florida Museum of Natural History; MVZ-Museum of Vertebrate Zoology, University of California, Berkeley; PLU-Pacific Lutheran University; PSM-Slater Museum of Natural History, University of Puget Sound, Tacoma; RM-Redpath Museum, McGill University, Montreal; UOK-University of Oklahoma, Oklahoma Museum of Natural History; USNM-U.S. National Museum, Washington D.C.; UWBM- University of Washington Burke Museum, Seattle; WSU-Charles R. Conner Museum, Washington State University, Pullman.

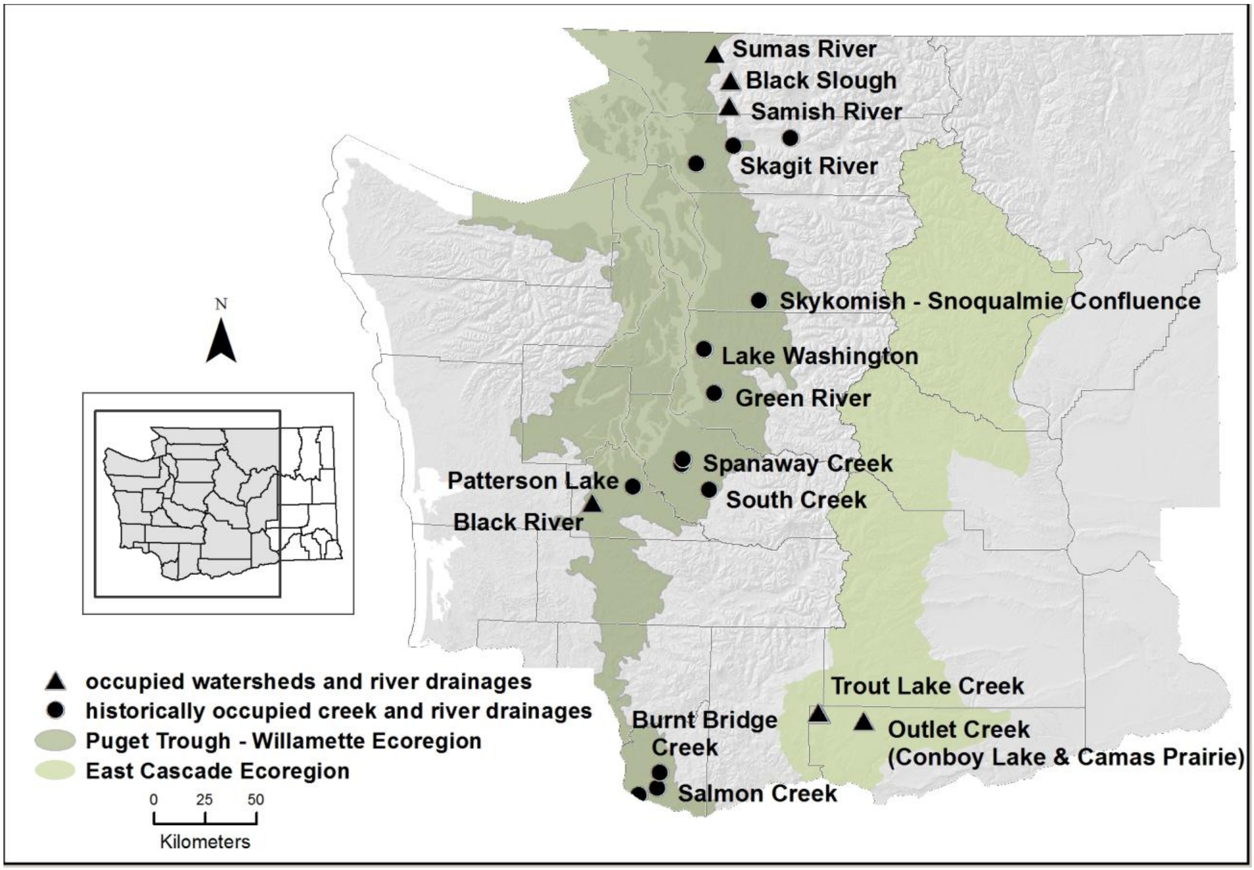

Figure 16. Washington drainages documented to have been occupied by Oregon Spotted Frogs.

Historical Abundance

Gathering information on the historical abundance of Oregon Spotted Frog is complicated by the taxonomic history of the species. Information written before about 1955 that refers to "Western Spotted Frog, *Rana pretiosa*" can include frogs now recognized as *R. pretiosa*, *R. luteiventris* or *R. cascadae* (Dickerson 1906, Slevin 1928, Svihla 1935, Wright and Wright 1949). Literature written between 1956 and 1996 often combines spotted frog species, *R. pretiosa* and *R. luteiventris* (Dumas 1966, Nussbaum et al. 1983, Cook 1984). Hence, historical information is limited to a few references that indicate specific locations identifiable as being within the range of Oregon Spotted Frogs (Dickerson 1906; Jewett 1936; Slipp 1940; Licht 1969; 1971a, b; 1974; 1975; 1986a, b; and J.W. Slipp's field notes from the Slater Museum of Natural History, University of Puget Sound). These observations provide scant information on historical abundance. Below is a summary of the quantitative information from journals, reports and biologist's field notes that provides some information.

British Columbia. Licht (1969) reported 30 egg masses in 1968 and 54 egg masses in 1969 from his study site in the Lower Fraser Valley near White Rock (called the Langley site).

Washington. Slipp (1940) indicated that Oregon Spotted Frogs in the Tacoma area occurred only in prairie lakes and streams. The Spanaway Lake area in Pierce County, located approximately 16 km (10 mi.) south of Tacoma, was occupied by Oregon Spotted Frogs until at least 1959 based on museum specimens (Pacific Lutheran University, museum specimens 40-43). Slipp's field notes indicate that he observed at least a dozen Oregon Spotted Frog males during one March 1939 visit to Little Spanaway Lake located in Spanaway Park. During a subsequent visit, he observed 6–7 egg clusters at the same location. He indicated that the frogs had used this same oviposition site for the previous two years. Wright and Wright (1949; p. 527) report a short trip with James Slater on 30 March 1942 to Spanaway Lake (written erroneously as "Sparaway"). During their trip they saw two frogs and captured a single Oregon Spotted Frog.

Oregon. Jewett (1936) reported that Oregon Spotted Frogs were common along the sloughs of the Willamette and Columbia rivers in the Portland area.

Surveys in the last 25 years at or near the above mentioned sites in British Columbia, Washington and Oregon have not detected Oregon Spotted Frogs. These results suggest that these areas no longer support the species. Causes of these extirpations are unknown. Licht (1974) hypothesizes that establishment of non-native bullfrogs at his Langley study site around 1970 presented a severe threat to the existence of Oregon Spotted Frogs. Haycock (2000) indicated that photographs taken at the time of Licht's study show the site was wet meadow covered predominately by bulrush (*Juncus effusus*), sedge (*Carex* sp.) and buttercup (*Ranunculus* spp.). Livestock were removed sometime after Licht's research ended and the land was transferred to Greater Vancouver Regional District. Without cattle grazing, willow and hardhack became well-established. A road was constructed approximately 300 feet west of Licht's site in the 1980s and may have altered the hydrology of the area (Haycock 2000). However, according to C. Bishop (pers. comm.), Licht visited the exact historical breeding site in 2011and reported that the vegetation and water levels looked exactly as it did when he conducted his research.

The south Puget Sound prairies of Washington, referred to by Slipp (1940), were reduced to about 10% of their former abundance (Crawford and Hall 1997) primarily due to agriculture and development. This likely impacted the associated wetlands, especially seasonally flooded areas that would have been easily drained and converted to uplands. In the Spanaway Lake area, bullfrogs were well-established by the early 1930s (Tobiason 2003). According to Slipp's field notes, his study site on Little Spanaway Lake was filled by the WPA (Works Projects Administration) sometime between March and May 1939 "obliterating" his original study site. The following year he observed a single cluster of egg masses about 25.5 cm (10 in.) across. The egg masses were in a new location where the frogs had not previously been breeding. An adult male was present at the egg mass cluster. The following year he recorded a single male in this same area but did not mention egg masses.

The sloughs of the Willamette and Columbia rivers near Portland where Jewett (1936) made his observations were degraded by development and urbanization. The Columbia Slough was altered to control flooding starting around 1910. Levies, dikes, water pumps and flood gates were installed and tributaries were piped or filled. In addition, sewage was pumped directly into the slough until 1952. Consequently Columbia Slough was one of Oregon's most polluted waterways until a lawsuit forced the state to act in the early 1990s (Center for Columbia River History 2011)

Current Distribution and Status in Washington

Oregon Spotted Frogs in Washington are known to persist in the following drainages: 1) Sumas River; 2) Black Slough; 3) Samish River; 4) Black River; 5) Outlet Creek; and 6) Trout Lake Creek (Fig. 12; McAllister and Leonard 1997, Bohannon et al. 2012). The Outlet Creek occurrences are primarily associated with Conboy Lake and Camas Prairie.

The population estimates that follow are based on census of egg masses during the spring breeding season of respective years (Appendix A). All known extant breeding areas in the three main population complexes (Black River, Trout Lake and Conboy Lake) were surveyed in 2012 (Table 3). Oregon Spotted Frog egg masses are relatively easy to detect and past experience suggest surveys detect a high proportion of egg masses laid at these sites. In addition, new occurrences were found on private property in

Whatcom and Skagit counties in both 2011 and 2012 (Table 3). Table 3 also includes an estimate of the number of breeding adults by drainage. These estimates assume one egg mass per adult female per year and one male breeding with each female (Phillipsen et al. 2009). The Black River had about 1,748 breeding adults (WDFW, WSDM database), Trout Lake had 2,124 breeding adults (Hallock, 2012), Conboy Lake had 1,954 breeding adults (M. Hayes and T. Hicks, pers. comm.), and Sumas River, Black Slough and Samish River had 90, 232 and 1,220 breeding adults respectively. The full extent of Sumas River, Black Slough and Samish River are not known. Summing these estimates, the total population at known sites in Washington for 2012 was at least 7,368 breeding adults.

Puget Trough Ecoregion

Sumas River population. In 2012, a total of 45 Oregon Spotted Frog egg masses were found on a privately owned dairy farm near the town of Nooksack on an unnamed tributary of the Sumas River (Fig. 17). Elevation in the area is about 27.4 m (90 ft.).

Table 3. Population census for Black River, Trout Lake, Conboy Lake, Sumas River, Black Slough and Samish River in 2012.

Population Complexes	Egg masses	Breeding adults
Black River		
Dempsey Creek	136	272
Salmon Creek	96	192
Blooms Ditch	0	0
Black River Flood Plain	480	960
Allen Creek	85	170
Beaver Creek	77	154
Trout Lake	1,062	2,124
Conboy Lake	977*	1,954
Sumas River	45	90
Black Slough	116	232
Samish River		
Whatcom Co. breeding areas SAM 2 & 6	157	314
Skagit Co. breeding areas SAM 8,11,12,14	443	886
Skagit Co. breeding areas SAM 7	10	20
Total	**3,684**	**7,368**

*Census results based on survey of Conboy Lake National Wildlife Refuge and one site on private land.

***Black Slough population*.** In 2011, Oregon Spotted Frog egg masses were found on two privately owned adjacent parcels near Van Zandt along the Black Slough (Gay and Bohannon 2011). Elevation in the area is about 73 m (240 ft.). A third breeding area, also on private property, was found in 2012 approximately 1,029 m (3,376 ft.) straight-line distance south of the two breeding areas found in 2011 (Fig. 17). Intervening habitat has not been surveyed but appears to be suitable. Based on separation distance and habitat suitability, these three areas likely form a single population. The three parcels had 10, 48 and 58 egg masses respectively for a total of 116 egg masses (Bohannon et al. 2012). Conservation District staff reported seeing egg masses at one of the sites (SF-1) in mid-March 2008 and again in March 2009 in off-channel wetlands dominated by reed canarygrass and recent tree and shrub plantings. At the time, they did not know the species of frog producing the egg masses.

***Samish River population complex*.** In 2011, Oregon Spotted Frog egg masses were found on two privately owned adjacent parcels near the headwaters of the Samish River near the town of Acme (Fig. 17; Gay and Bohannon 2011). Based on proximity, they likely form a single breeding population (SAM 2 & 6). In 2012, five additional breeding areas were found on the Samish River in Skagit County (Bohannon et al. 2012) with the closest being 4.86 km (3.0 mi.) from SAM-2 & 6. Egg mass clusters at sites identified as SAM- 11, 14, 12 and 8 were distributed along 1.8 km (1.12 mi.) of the river. Based on distance between sites (<2.0 km) and apparent suitability of intervening habitat, these four breeding areas are likely part of the same breeding population. The fifth breeding site (SAM-7) is located approximately 3.04 km (1.9 mi.) to the south of SAM-8. The elevations are 70-89 m (230–290 ft.). These three concentrations of Oregon Spotted Frog breeding sites are probably too far apart to have regular exchange of breeding individuals, however, little is known about the intervening areas at this time and whether or not they are occupied by Oregon Spotted Frogs. The three breeding clusters combined (SAM-2&6; SAM-8, 11, 12 & 14; and SAM-7) had 157, 443 and 10 egg masses respectively for a total of 610 egg masses in the drainage.

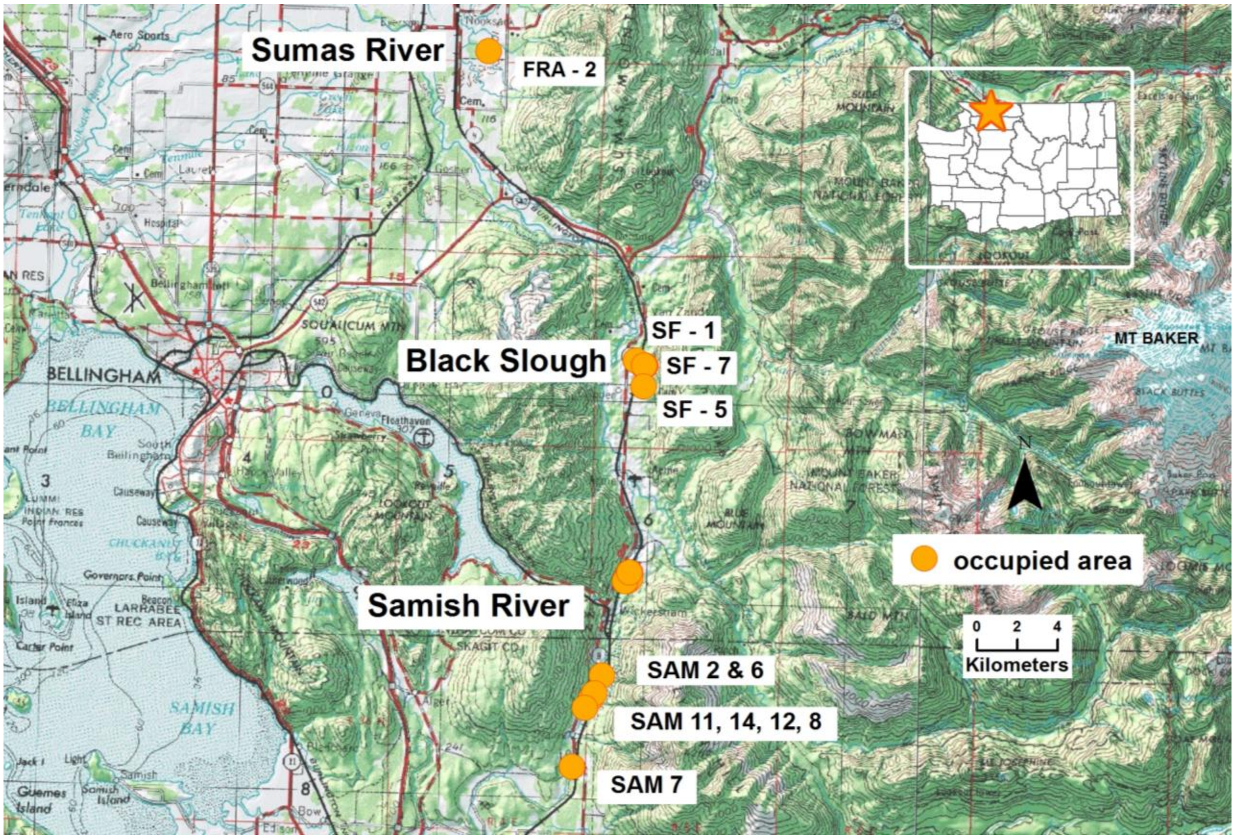

Figure 17. Oregon Spotted Frog occurrences in the Sumas River, Black Slough and Samish River.

Black River population complex. Oregon Spotted Frogs occupy the Black River floodplain and its tributaries between Black Lake and the town of Littlerock in the Puget Sound lowlands. Elevations in the occupied areas are 40–58 m (131–190 ft.). Five additional occupied areas have been found since Oregon Spotted Frogs were first documented at Dempsey Creek in 1990 (Fig. 18; McAllister et al. 1993, Watson et al. 2000, McAllister and Walker 2003, McAllister et al. 2004a, and efforts by K. McAllister, S. Freed, J. Wallace, M. Tirhi, T. Schmidt and B. Blessing Earle). The subpopulations are named after the tributary in which they occur: Dempsey Creek, Salmon Creek, Blooms Ditch (near 110th Avenue Bridge), Black River Flood Plain (near 123rd Avenue), Allen Creek, and Beaver Creek.

The relationship, if any, between the occupied areas is poorly understood. Especially lacking is information on juvenile frog dispersal. McAllister et al. (2004a) trapped three miles along the Black River to gather information on connectivity between known breeding areas. They were able to show that marked frogs (n = 3) moved down Dempsey Creek to the Black River, a creek distance estimated to be 2,360 m (7,750 ft.). Beyond the spotted frog occurrence near the mouth of Dempsey Creek (The "Pipeline"), they found no evidence that Oregon Spotted Frogs exist along the Black River to Blooms Ditch. The other occupied areas may also be isolated from each other by creek distances that exceed the length of movements typical for ranid frogs (<5 km: Hammerson 2005), and Oregon Spotted Frogs have not been documented to move further than 2.8 km (1.7 mi.; Forbes and Peterson, 1999). The exception may be between Blooms Ditch near 110th Avenue and Black River Flood Plain near 123rd Avenue where separation distance is less than 5 km, however, no evidence of breeding has been observed at Blooms Ditch since 2005.

Oregon Spotted Frogs in the Dempsey Creek system have been intensively studied and monitored since 1996 (Leonard et al. 1997a; Leonard et al. 1997b; Watson et al. 1998, 2000, 2003, McAllister et al. 2004a, b; and ongoing monitoring and research). Information about the other subpopulations consists primarily of egg mass censuses and inventory.

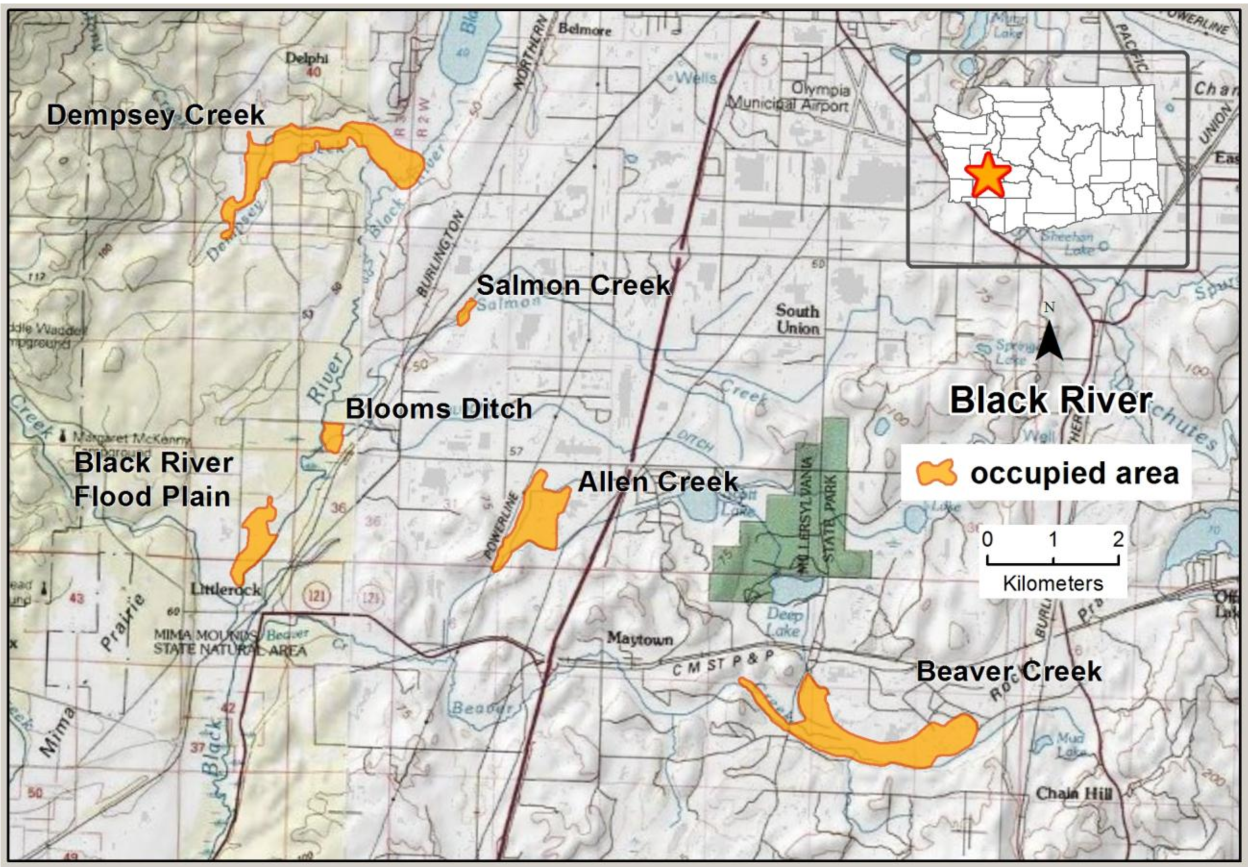

Figure 18. Extent of known Oregon Spotted Frog habitat in the Black River watershed, Thurston County, Washington (Townships 16 & 17 North, Ranges 2 & 3 West).

<u>Dempsey Creek</u>. Oregon Spotted Frogs occupy Dempsey Creek, including its associated tributaries (e.g., Stony Creek) and wetlands, from the headwaters to the confluence with the Black River. Elevations along the creek are 40–43m (130–140 ft.). Lands along the upper drainage are in different ownerships. The most significant properties for Oregon Spotted Frog conservation are referred to as The Dairy Farm, Musgrove site, and The Forbes. Dempsey Creek flows through these properties in the order listed with The Forbes property extending all the way to the Black River. These properties are in close proximity and the frogs that inhabit them are a single population. The only occurrence of spotted frogs known in the lower part of the drainage is at the confluence of Dempsey Creek and the Black River in an area called The Pipeline.

Egg mass censuses have been conducted in the upper drainage since 1996 (Fig. 19; Appendix A). Inventory and monitoring has differed depending on land ownership. Numbers fluctuated from year to year ranging from 117–384 egg masses indicating a population of about 234–666 adults. No overall pattern of decline was observed. Some of the variation in egg masses is related to the amount of survey effort each year and whether or not all properties were surveyed. Familiarity with Oregon Spotted Frog breeding habits and habitat also influenced the census resulting in more accurate egg mass counts in later years. Changes in land management, such as cessation of grazing from 2006–2008 and habitat restoration at the Musgrove site in 2008, may have also influenced egg mass numbers and survival.

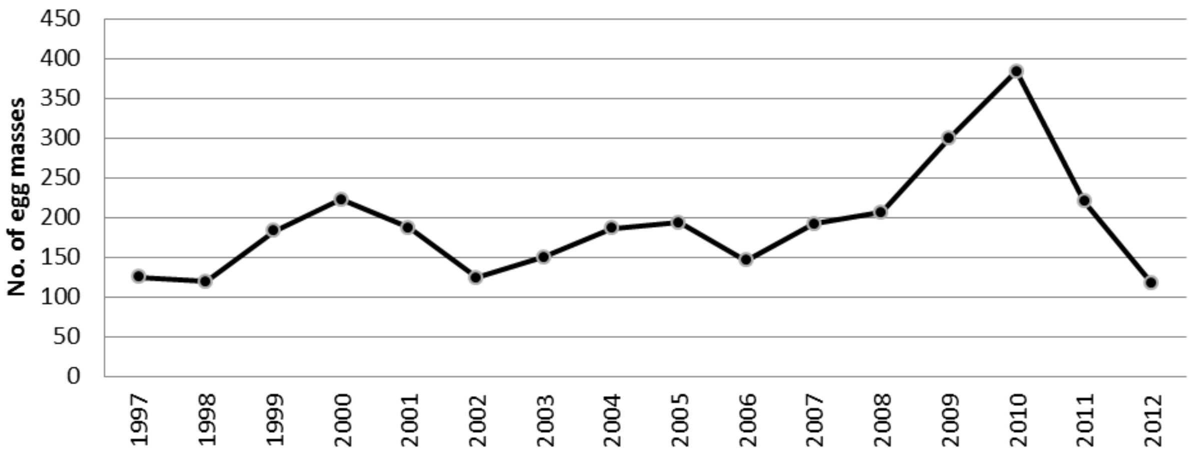

Figure 19. Egg mass census for all sites monitored in the upper drainage of Dempsey Creek (i.e., The Dairy Farm, Musgrove and The Forbes) from 1996–2012 (Data from K. McAllister 1996-2006; L. Hallock 2007; B. Murden 2008-2012).

The Dairy Farm. This property is not managed for Oregon Spotted Frogs but has been surveyed for egg masses. Survey effort and area have been highly variable from year to year. The site supports 80–200 breeding adults in some years but in 2012, only six egg masses were found (M. Bailey, pers. comm.). U.S. Fish and Wildlife Service (hereafter USFWS) took ownership in 2012.

Musgrove Parcel. This is a small (<1 ac.) parcel that is owned by USFWS. The Musgrove parcel was completely overgrown by dense reed canarygrass resulting in unsuitable Oregon Spotted Frog habitat. In 2008, the reed canarygrass was mowed and cattle were reintroduced to the site. The first year following treatment, Oregon Spotted Frogs laid eight egg masses at the restored site. In 2010 and 2011, 49 and 37 egg masses were laid respectively (Bailey 2011). In 2012, only 18 egg masses were found (M. Bailey, pers. comm.). It is not known if the breeding adults moved to the restored habitat from The Dairy Farm, The Forbes or from elsewhere in the drainage.

The Forbes. The most extensive Oregon Spotted Frog habitat in the Dempsey Creek drainage occurs on lands owned by Port Blakely Tree Farms. Breeding sites have been monitored consistently on The Forbes property since 1996 (Fig. 20, Appendix A). Egg mass numbers fluctuated from year to year ranging from 82–238 egg masses indicating a population of approximately 164–476 breeding adults.

Confluence of Dempsey Creek and Black River (The Pipeline). This site was discovered in 2003. Ownership is a mix of private and USFWS refuge lands. In 2003 and 2004, egg mass numbers were 94 and 108 (K. McAllister, unpubl. data summarized in USFSW 2009), suggesting a population of at least 188–216 adults. No surveys were conducted 2005–2007. Survey results from 2008–2010 were 64, 15 and 0 egg masses respectively even with increase survey effort starting in 2009 (T. Schmidt, pers. comm.). In 2011 and 2012, inventory efforts increased again and new areas were surveyed. This resulted in new oviposition areas being found with a total of 36 and 19 egg masses for 2011 and 2012 respectively (T. Schmidt, pers. comm.). The reason for the decline is unknown but changing water levels are suspected.

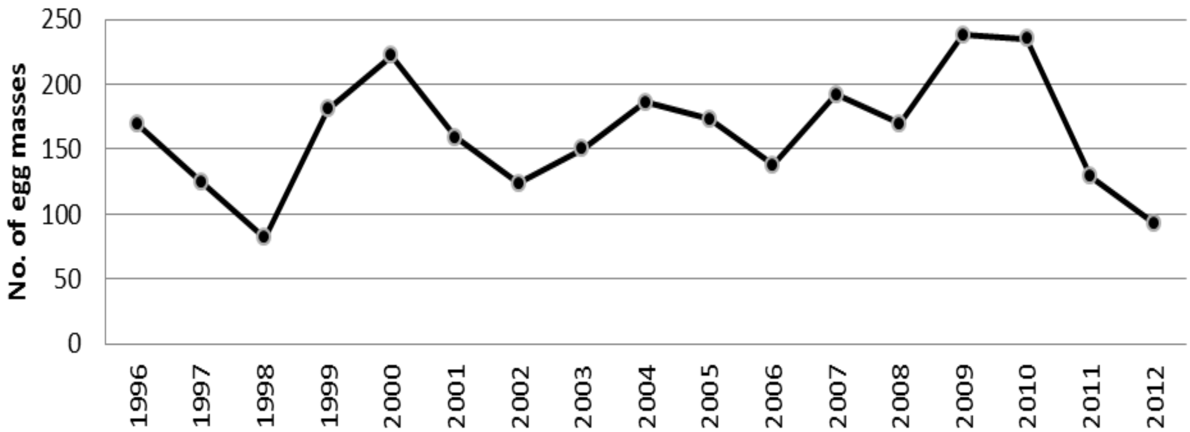

Figure 20. Egg mass census for The Forbes from 1996-2012 (Data from K. McAllister, 1996-2006; L. Hallock, 2007; B. Murden, 2008-2012).

Salmon Creek. A breeding aggregation of Oregon Spotted Frogs was found on private property in the Salmon Creek drainage in 2010 (B. Blessing Earle, pers. comm.). Elevation at this site is 52 m (170 ft.). Twenty-seven egg masses were found the first year indicating a population of about 54 adults. In 2011 and 2012, survey effort was increased and 58 and 96 egg masses were found on the same privately owned parcel. The extent of occupation within this drainage is not yet known.

Blooms Ditch (also called 110th site). A very small breeding aggregation of Oregon Spotted Frogs was found on USFWS refuge property (Black River Unit of the Nisqually National Wildlife Refuge) in 2001. Elevation is 43 m (140 ft.). The frogs were discovered after a restoration project on the property. Only 1–4 egg masses were found annually 2001–2005 (McAllister and Walker 2003; K. McAllister, pers. comm.). After that, no evidence of breeding was found (L. Hallock, pers. obs. 2007 survey, M. Bailey, pers. comm. regarding 2008-2010 surveys). About four years after restoration, the site was completely overgrown by tall, dense, thatched reed canarygrass that eliminated most suitable spotted frog oviposition habitat (M. Bailey, pers. comm.). The small size of the population and the lack of suitable habitat are the most likely explanations for the extirpation of this occurrence. The site was not surveyed in 2011 or 2012.

Black River Floodplain (also called 123rd site). This property supports the largest breeding aggregation in the Black River population complex. It is located on the Black River Unit of the Nisqually National Wildlife Refuge at an elevation of 43 m (140 ft.). Interpretation of long-term egg mass trends is complicated by inconsistencies in monitoring between years (Appendix A). In 2008, monitoring efforts were greatly increased over previous years and by 2009, the refuge had established a monitoring protocol that included use of volunteers to do the annual egg mass census (M. Bailey, pers. comm.). As a result, the full extent of the population was documented resulting in 685, 574, 591 and 480 egg masses being found in 2009–2012 respectively indicating that about 960–1,370 spotted frogs breed on this property (M. Bailey, pers. comm.).

Allen Creek. This site was discovered in 2008 on private property. Elevation is about 58 m (190 ft.). In 2011, a total of 246 egg masses were found on four parcels indicating a population of at least 492 adult frogs but in 2012, only 85 egg masses could be found in the same survey area (T. Schmidt, pers. comm.).

Beaver Creek. This site was discovered in 1999. WDFW subsequently acquired the property as part of the West Rocky Prairie Wildlife Area. Elevation is 64–67 m (210–220 ft.). Monitoring has consisted of egg mass counts in eight years from 1999–2012 (Appendix A). The highest count was 123 egg masses in 2000 indicating a population that year of about 246 adults (K. McAllister, pers. comm.). The population size has declined since that time. From 2010–2012, the census was 76, 44 and 77 egg masses respectively suggesting a population of about 88–154 adult frogs (M. Hayes, J. Tyson and R. Johnson, pers. comm.).

Dailman Lake reintroduction site. A reintroduction project was initiated in 2008 at Dailman Lake in Pierce County on Joint Base Lewis-McChord Military Reservation (JBLM). Elevation is 97.5 m (320 ft.). Dailman Lake is located in the Muck Creek drainage. The reintroduction site is about twelve miles west of the historical Kapowsin site and about seven miles south of the historical Spanaway sites (Table 2). The Kapowsin collection site was probably in the South Creek drainage, a tributary of Muck Creek and the Spanaway sites were in Spanaway Creek in the Chambers-Clover watershed but the intervening area between Muck Creek and Spanaway Creek is relatively flat and covered by a series of wetlands. The eggs for reintroduction were collected from the Black River and the Conboy Lake population complexes for five years (2008-2012). The tadpoles were captive raised until metamorphosis and then released in the fall of each year. As of November 2012, about 5,490 frogs were released. The first evidence of breeding by the reintroduced population was found in April 2011 when three verified Oregon Spotted Frog egg masses and eleven egg masses suspected to be Oregon Spotted Frogs were found by WDFW and JBLM biologists. Field verification was not possible for the latter egg masses because they were laid in singles, doubles and/or were loosely aggregated; traits occasionally also seen in Northern Red-legged Frog egg masses (L. Hallock, pers. ob.). Eleven embryos from both the confirmed and unconfirmed egg masses were collected for genetic verification and confirmed to be Oregon Spotted Frogs (K. Warheit, WDFW genetics laboratory, pers. comm.). In 2012, no eggs resembling those of Oregon Spotted Frog were found by WDFW and JBLM biologists. The project is being evaluated in 2013 to determine success to date and if additional releases should continue.

East Cascades Ecoregion

Trout Lake population complex. Oregon Spotted Frogs occupy the lower Trout Lake Creek watershed from 597–633 m (1,960–2,080 ft.) elevation (Fig. 21). The watershed is located on the south side of Mount Adams in south-central Washington in Klickitat and Skamania counties. The nearest town is Trout Lake. Oregon Spotted Frogs were historically documented at Trout Lake and the old town of Guler. Inventory in recent years in the Trout Lake Creek drainage has expanded the known area to include all of the lower Trout Lake Creek drainage (Leonard 1997, Hallock 2009, 2012). The primary occupied area is an ancient lake bed formed approximately 6,000 years ago (Vallance 1999) that is now a palustrine wetland and riparian system without limnetic (lake) habitat (Cowardin et al. 1979). The palustrine wetland (hereafter referred to as the “wetland”) is located in the lower portion of the orange polygon in Fig. 21. Most Oregon Spotted Frog habitat in the Trout Lake watershed is protected as a Natural Area Preserve (NAP), managed by the Washington Department of Natural Resources’ Natural Areas Program. In addition, the U.S. Forest Service manages a beaver pond on the Gifford Pinchot National Forest that is occupied by Oregon Spotted Frogs and another small occupied pond occurs on private land.

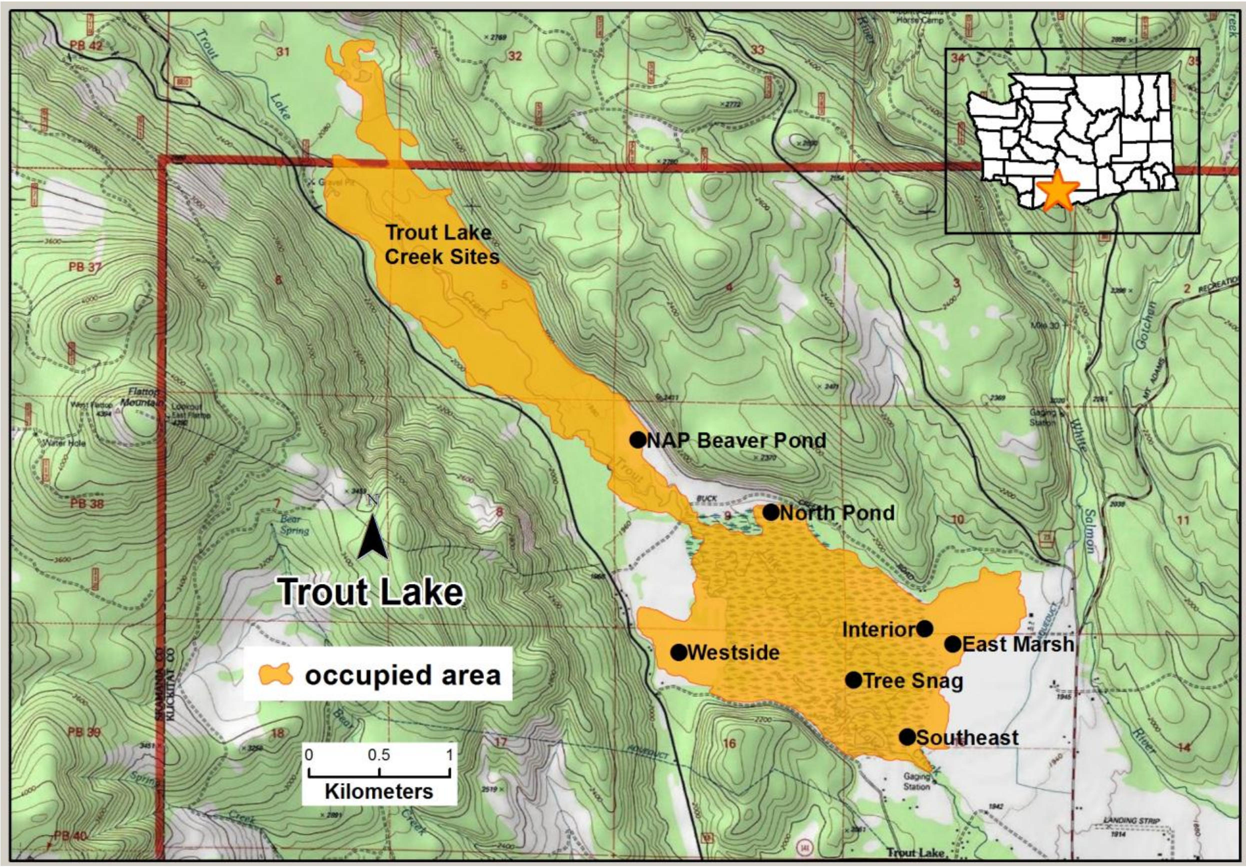

Figure 21. Extent of known Oregon Spotted Frog habitat in the Trout Lake Creek watershed, Klickitat County, Washington (Township 6 North, Range 10 West).

Leonard (1997) identified five major breeding areas including two on the western wetland edge (“Westside”) and three on the eastern wetland edge (“East Marsh” or “East of Creek”). The Westside and East Marsh breeding sites are approximately 2 km (1.2 mi.) apart. He also found a breeding site approximately 4 km (2.48 mi.) north of the main wetland in habitat adjacent to Trout Lake Creek. In 2001, a new breeding area was found near the East Marsh breeding areas (“Interior”; Lewis et al. 2001). In the same year, a second site was found about 4 km (2.48 mi.) north of the main wetland in the Trout Lake Creek floodplain. Four additional breeding areas were found in 2007 and 2010 (Hallock 2012): “North Pond” is located at the northern edge of the wetland, “Tree Snag” is located in the middle of the wetland and “Southeast” is located in the southeast corner of the wetland. A fourth site, called NAP Beaver Pond, is located along the Trout Lake Creek floodplain in a beaver created wetland less than a kilometer (0.6 mi.) from the main wetland. The breeding areas are labeled on Fig. 21.

In total, twelve breeding areas have been identified. The Westside and East Marsh breeding areas have been monitored each year since their discovery. The other locations have been monitored regularly but not annually since they were discovered (Appendix A). Numbers of egg masses at the Westside and East Marsh breeding areas have varied considerably over the 15 year period from 1997–2012 (Fig. 22). Counts in both areas declined in early and mid- 2000s, followed by an increase after 2007. Egg mass numbers at the Westside sites dropped from >400 to a low of 12 egg masses in 2007, despite expanded search efforts.

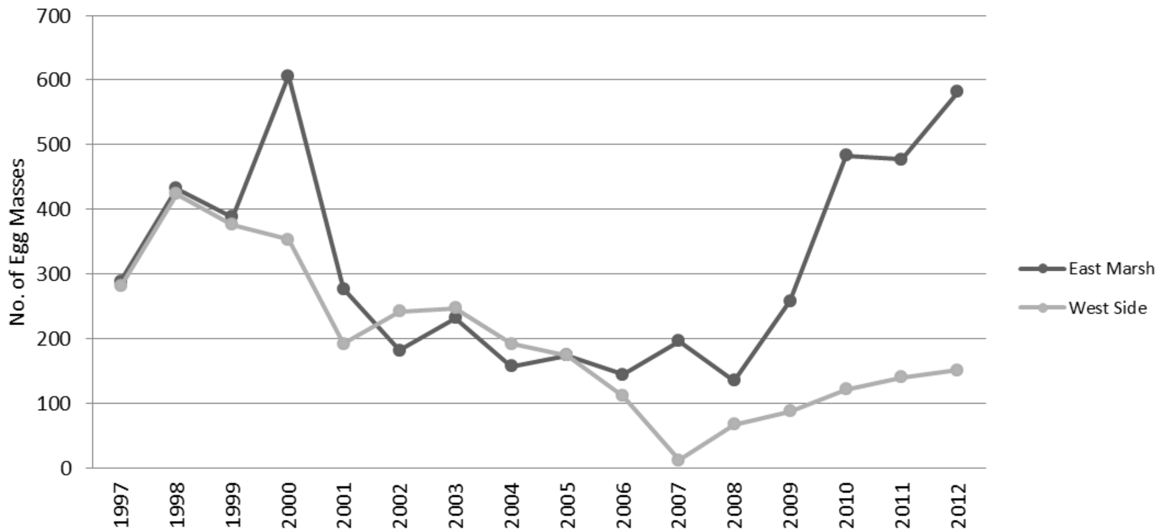

Figure 22. Egg mass census trends for Trout Lake breeding areas monitored 1997-2012 (Leonard 1997, Lewis et al. 2001 and Hallock 2012).

Several potential stressors to Oregon Spotted Frogs were noted at Trout Lake habitats over the monitoring period: 1) Annual precipitation was unusually low; 2) Cattle grazing changed at the site (reduced/modified in 2001, ceased entirely in 2005); and 3) Frogs infected with chytrid fungus (*Batrachochytrium dendrobatids, Bd*) were present (Pearl et al 2009a, Hayes et al. 2009).

Precipitation and inundation conditions are associated with changes in other amphibians, and are a likely contributor to lower Oregon Spotted Frog breeding numbers between 2001 and 2008. Precipitation data comes from Mt. Adams Ranger District weather station located 0.8 km (0.5 mi.) from Trout Lake wetland. Weather data has been collected at this weather station since 1925 (Appendix B). Long-term, average annual precipitation at the Mt. Adams Ranger District was 41.7 in. (106 cm). From 2000–2005, precipitation was consistently below long-term climatological normals. Annual precipitation fell below 30 in. (76.2 cm) annually only nine times from 1925–2010. Perhaps noteworthy is the fact that it did so twice (2000, 2004) leading up to and during the period of egg mass decline and those years were the third and fifth lowest annual precipitation levels recorded in 84 years. Annual precipitation from 1995–1999, when egg mass numbers were high, was above average (41.7 in.) in all five years (48.92–55.64 in.)

Most precipitation falls October to March at Trout Lake. Those months, during the two most severe drought years of 2000–2001 and 2004–2005, had extremely low precipitation compared to more typical years (Appendix B); 9.3 in. (23.6 cm) and 16.4 in. (41.7 cm) respectively compared to an average precipitation of 34.9 in. (88.6 cm). Hallock and Pearson (2001) reported 38% mortality of radio-tracked females from December 2000 to the end of their study in January 2001. Loss of adult females during winter would be reflected by a drop in the number of egg masses produced the following spring. While such a drop did occur in spring 2001, no similar decline was documented in spring 2005. It should be noted, however, that declining precipitation levels were not as severe October to March 2004–2005. Extended multi-year periods of low precipitation may have stressed other life stages and this may have been reflected over a longer time period as recruitment to adult breeding size gradually declined. A stressed population may also have been more susceptible to disease. Perhaps significant is the fact that egg mass numbers started increasing following above average annual precipitation in 2006 with two additional years (2007, 2009) of near average precipitation. Coinciding with increased precipitation was the installation of a water control structure in the southeastern area of the wetland in the fall 2005. The impact of this structure included longer retention and slower draining of water east and north of the structure including the East Marsh and Interior breeding areas. The Oregon Spotted Frog breeding aggregation at the East Marsh and Interior breeding areas started to recover in 2009 and had reached sizes similar to those recorded in the late 1990s by 2010–2012 while recovery of the Westside breeding aggregation has been slower and remains below the numbers seen in the late 1990s.

Conboy Lake population complex. The Conboy Lake population complex is located in the southern portion of Glenwood Valley in Klickitat County (Fig. 23). The nearest town is Glenwood. Oregon Spotted Frogs occupy the historical Conboy Lake bed and Camas Prairie wetland system (Hayes et al. 2000) that cover an area of about 2,968 ha (7,335 ac.; Fig. 23). They were first discovered at Conboy Lake National Wildlife Refuge in 1992 by Dennis Paulson during fieldwork on dragonflies (M. Hayes, pers. comm.).

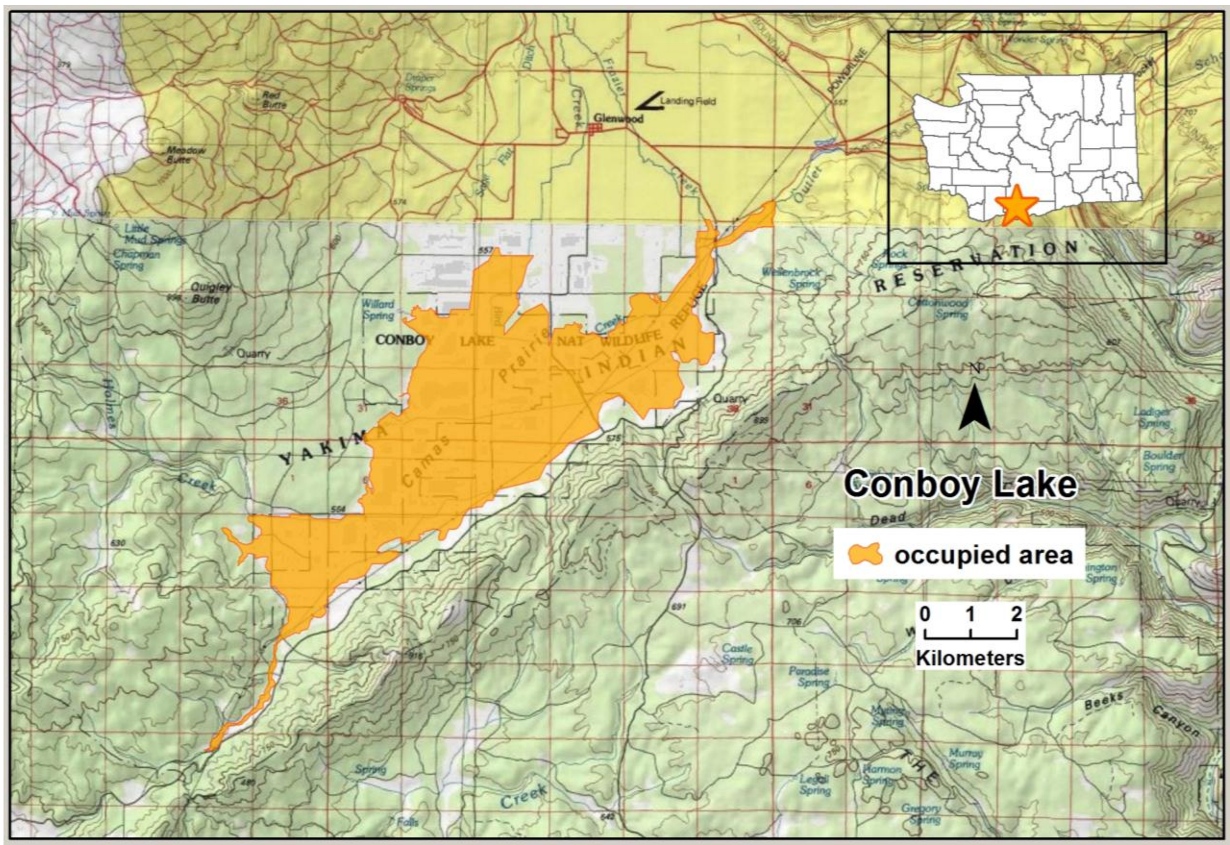

Figure 23. Estimated extent of Oregon Spotted Frog habitat at Conboy Lake, Klickitat County, Washington (Townships 5 & 6 North, Ranges 11 & 12 East).

Oregon Spotted Frog egg mass monitoring was initiated in 1998 (Fig. 24, Appendix A). The initial survey covered the entire Conboy Lake National Wildlife Refuge and egg masses were found on seventeen management units. The results revealed Conboy Lake to have the largest Oregon Spotted Frog population known to exist throughout the entire range with an egg mass census of 7,018 (about 14,036 breeding adults; Hayes et al. 2000). Survey of selected adjacent private lands has occurred irregularly since the initial surveys in 1998; Oregon Spotted Frog egg masses were found on all private lands that were surveyed. The following year egg mass numbers on the refuge dropped to 5,434, even with additional survey effort. The decline was attributed to removal of a series of beaver dams on the system-draining stream, Outlet Creek, in the fall of 1997. Without the beaver dams, water within some breeding areas was not retained as long and this resulted in high embryo mortality due to stranding (Hayes et al. 2000).

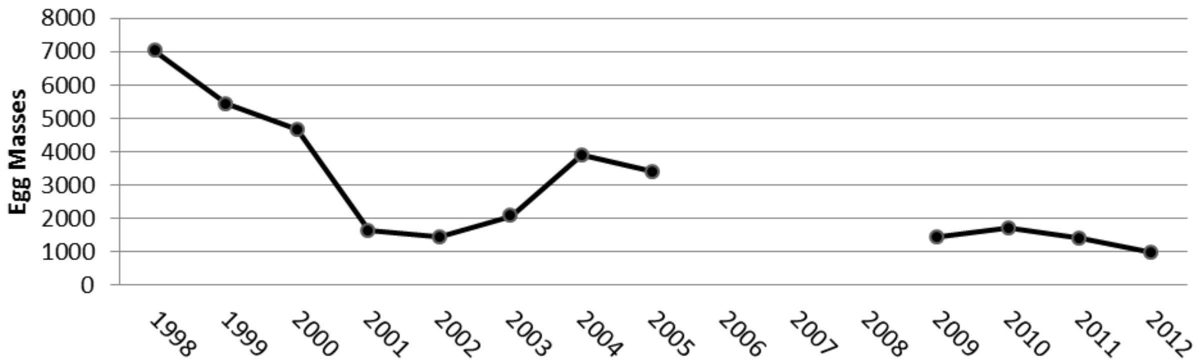

Figure 24. Egg mass census trends for Conboy Lake breeding sites monitored 1998-2012 (USFWS 2009 and M. Hayes and T. Hicks, per. comm. 2009-2012).

Even with hydrological fixes, egg mass numbers only partially recovered in succeeding years (Fig. 24, Appendix A). In 2006–2008, only a subset of units were surveyed but showed an additional decline was underway (Appendix A; M. Hayes, pers. comm.). Hayes et al. (2009) suggested that disease might be responsible for the post-2005 decline when Oregon Spotted Frogs were found to be infected with amphibian chytrid fungus. However, assessments found the disease to be widespread and common among Oregon Spotted Frogs (Pearl et al. 2007) and testing of post-metamorphic juveniles obtained from Conboy Lake in 2009 revealed that they could rapidly shed this infection (Padgett-Flohr and Hayes 2011). These findings make it less likely that the declines that have continued post-2005 were caused by chytrid infection. Overall, the population declines post-2005 have continued and the annual survey in 2012 found only 977 egg masses; an 86% loss of egg mass production since1998.

Undiscovered populations. Even with increased awareness about the plight of the species, only three new occupied drainages were discovered in Washington since the mid-1990s. This supports the idea that Oregon Spotted Frogs are now extremely limited in distribution. Genetic evaluation of the species by Blouin et al. (2010) also supports the notion of a discontinuous distribution for Oregon Spotted Frogs including evidence that the remaining populations have been isolated from each other since before European colonization. As shown by the new populations found in Whatcom and Skagit counties in 2011–2012, however, the possibility remains that undiscovered populations may still occur on private lands that have not been accessible for inventory.

WASHINGTON HABITAT STATUS

Past

Habitat loss, degradation and fragmentation are thought to be the main factors responsible for the decline of Oregon Spotted Frogs in Washington (McAllister and Leonard 1997). This likely began with the overtrapping of beaver in the 19th century. By 1900, the ubiquitous beaver had been nearly extirpated in the continental United States (Feldhamer et al. 2003). More environmental changes followed as Euro-American settlers moved to Washington in increasing numbers during the late 1800s. River valleys, including associated wetland habitats, were flat and fertile making them ideal locations for agriculture and residential development. Starting around the turn of the 20th century, great efforts were made to control water conveyance and delivery in Washington. Extensive systems of dams, ditches, berms and tile drains were installed for agricultural use and to decrease variability of water resources. Concurrently, the rivers and creeks that fed and drained wetlands were forced into channels ending their meandering and subsequent creation of oxbows and off-channel wetlands. Little consideration for the ecological dynamics of riparian/steam ecosystems were incorporated into these changes (Elmore and Kauffman 1994).

Another major change that occurred as Euro-American settlement increased in the mid-1800s was the end of anthropogenic burning in western Washington and parts of eastern Washington (e.g. Conboy Lake/Camas Prairie). Before this time, indigenous peoples influenced the distribution, abundance and availability of wild plant resources, as well as desired habitats, by using low-intensity, high-frequency fires on a regular basis (every 1-2 years). This enabled them to manage large landscapes and contributed to the long-term maintenance and distribution of prairies and open savannahs, as well as keeping plants in early to mid-seral stages and enhancing the diversity and yield of useful plants and animals (Storm and Shebitz 2006, Hamman et al. 2011). Burning removed dry grass, created forest openings, kept understories more open and likely also set back succession in seasonal wetlands on the edges of burned terrestrial habitats ~ the latter being an essential condition for Oregon Spotted Frog oviposition habitat.

Modern land use practices (e.g. logging, clearing land for agriculture, development) increased the occurrence of non-permeable surfaces and altered hydrology by changing the rate and timing of water entering wetland systems. Forests and wetlands retain water and release it slowly through subsurface or ground water. The non-permeable surfaces associated with development and other less vegetated habitats (i.e., pasture, logged areas) convey water as surface runoff (Smith and Wenger 2001) and increased sedimentation into aquatic habitats. Loss of prairie habitat surrounding wetlands also may have impacted some Oregon Spotted Frog occurrences in Puget Sound (Slipp 1940).

Based on conservative estimates, Washington lost over 33% of its wetlands between pre-Euro-American settlement conditions and the 1980s (Canning and Stevens 1990). This percentage accounts for complete loss from draining or filling, but does not account for alteration or degradation. Freshwater marshes and forested wetland experienced the greatest losses. Snohomish County estimated wetland losses of 180 acres (72 ha) per year during the 1990s. Assuming a similar rate, losses for the eight urbanized counties with similar growth projections plus King and Pierce counties would be 1,800 acres (728 ha) per year (Canning and Stevens 1990). These counties are primarily in the Puget Sound Ecoregion where the majority of the historic distribution of Oregon Spotted Frogs in Washington had been documented (McAllister and Leonard 1997). More specifically, case studies in Washington showed losses of freshwater wetland acreages reflected on US Geological Survey quadrants to be 55% for Tenino and Yelm (south Thurston County), 82% for Tacoma South (Pierce County), and 70% for Lake Washington (King County) (Boule et al. 1983). Recent data (i.e., last 15 years) on wetland changes in Washington are lacking, in part, because of assumptions that changes to the Clean Water Act ("no net loss" policy) should have prevented additional losses.

Less easily calculated are the changes that have altered wetlands from their original condition. Examples of such activities include incomplete or seasonal drainage, major water withdrawals, impoundments as well as upland changes that have changed hydrological regimes. Also, significant is the introduction of exotic flora that in some cases, such as reed canarygrass, is able to exclude native flora, create dense thatched mats and trap sediment (see Habitat Quality, Condition, Continued Loss and Fragmentation).

Another major change affecting wetlands was the introduction of exotic predators dissimilar to those that occurred naturally in these systems. These included many warmwater fish species, coldwater salmonids and bullfrogs. The non-native Green Frog, (*Rana clamitans = Lithobates clamitans*), while still rare in Washington, is of concern for Oregon Spotted Frog populations in Canada (Haycock 2000) and perhaps for populations in Whatcom County. Exotic crayfish are of concern for some Oregon populations (Pearl et al. 2005b), but unexamined in Washington. Impacts from these species are thought to be both direct and indirect (see Non-native Animal Species in Factors Affecting Continued Existence section).

Present

Oregon Spotted Frogs occupy about 3,825 ha (9,454 ac.) of wetland in Washington including about 388 ha (959 ac.) in Thurston County (Puget Sound Ecoregion), about 3,432 ha (8,483 ac.) in Klickitat County and about 5 ha (12.35 ac.) in Skamania County (the latter both in East Cascades Ecoregion). These estimates were derived from polygons digitized from aerial photographs using Esri's ArcGIS 9.0 geospatial processing program, ArcMap (Figs. 18, 21 and 23; Table 4). The extent of habitat occupied in Whatcom and Skagit counties has not been determined.

The U.S. Fish and Wildlife Service manages about 2,390 ha (5,903ac.) of this habitat on the Conboy and Nisqually National Wildlife Refuges, and the U.S. Forest Service manages about 5 ha (12.35 ac.) on the Gifford Pinchot National Forest. State agencies manage about 612 ha (1,514 ac.) at Trout Lake and on Beaver Creek in the Black River watershed. The remaining 818 ha (ca. 2,024 ac.) are in private ownership with approximately 100 ha (247 ac.) in ownerships that manage for the Oregon Spotted Frogs (Port Blakely Tree Farms at Dempsey Creek, and a private owner on Salmon Creek). The new sites found in the Sumas River, Black Slough and Samish River drainages are all on private property.

Table 4. Area occupied by Oregon Spotted Frogs in Washington.

Occupied Drainage	County	Hectares	Acres	Ownership
Sumas River	Whatcom	Unknown	Unknown	Private
Black Slough	Whatcom	Unknown	Unknown	Private
Samish River	Whatcom, Skagit	Unknown	Unknown	Private
Black River	Thurston			
Dempsey Creek		123	304	Private, USFWS
Salmon Creek		5	12	Private
Blooms Ditch		12	30	USFWS
Black River Flood Plain (123rd)		38	94	USFWS
Allen Creek		62	153	Private
Beaver Creek		148	366	WDFW
Trout Lake	Skamania, Klickitat	469	1160	DNR, USFS, Private
Conboy Lake	Klickitat	2,968	7,335	USFWS, Private
Total		**3,825**	**9,454**	

Puget Trough Ecoregion

Sumas River population. The extent of Oregon Spotted Frog occupation within the Sumas River watershed is currently unknown. A single breeding aggregation was found in 2012. Egg masses were laid in a shallow, flooded pasture on a privately owned dairy farm (Fig. 17). The Sumas River flows north into the Frasier Valley of Canada and is a tributary of the Chilliwack River.

Black Slough population. The extent of Oregon Spotted Frog occupation within this watershed is currently unknown. Egg masses were found on three privately owned properties in 2011–2012. The two adjacent properties (SF-1 & SF-7) known to be occupied along Black Slough are similar in having a mix of riparian and wetland habitat and both parcels were also planted with shrubs and trees in 2009–2011 to improve riparian habitat for salmon and to shade reed canarygrass as part of the Conservation Reserve Enhancement Program (CREP) (Fig. 17, Gay and Bohannon 2011). One of the parcels (SF-1) was also re-contoured. This effort created several deeper ponds and higher areas for tree establishment. It is possible that some Oregon Spotted Frog breeding habitat was excavated as a result (Gay and Bohannon 2011). The adjacent parcel (SF-7) was mowed in May/June 2010 and again in August/September 2010 to facilitate shrub and tree survival. The third known breeding area found in the watershed (SF-5) consists of a pasture along a shallow slough. The slough is fenced off from cattle. Vegetation is reed canarygrass dominated with young CREP shrub and tree plantings.

***Samish River population complex*.** The extent of Oregon Spotted Frog occupation within this watershed is currently unknown. Egg masses were found on six privately owned properties in 2011-2012 (Fig. 17). The northern most properties (SAM-2 & 6) at the Samish River headwaters are owned by Whatcom Land Trust and were acquired in 2009 as part of the Samish River Preserve. The parcels have a mix of riparian, wetland habitat and pasture lands. The areas used by the spotted frogs for oviposition are dominated by reed canarygrass. At site SAM-2, Whatcom Land Trust has entered a 13-year agreement with the National Resource Conservation Service (NRCS) to enhance habitat for salmon by mowing, disking the soil and tree planting along the river (Gay and Bohannon 2011, J. Bohannon, pers. comm.). The site was grazed by cattle prior to the Whatcom Land Trust's purchase. Most of the site is dominated by reed canarygrass but there are scattered shallow pools that are sparsely vegetated. SAM-6 is a grazed pasture with two large ponds and a large emergent wetland. It was acquired by Whatcom Land Trust spring 2012. At that time, a single grazing bull was removed. This property is also under NRCS contract for salmon habitat enhancement.

Oviposition sites on properties SAM-11, 14, 12 and 8 were found over a 1.8 km (1.12 mi.) stretch of the river. Properties SAM-11, 14 and 12 are adjacent to each other and the Samish River flows through each one in the order listed with wetlands surrounding the river. SAM-11 is a large cattle-grazed pasture adjacent to a large wetland complex. Cattle are excluded from the wetland by fencing. Oviposition areas were found in the shallow, seasonally flooded, reed canarygrass dominated areas along the western edge of the wetland complex. The SAM-14 property has a network of shallow streams that flow through the property and drain into a wetland. The site is lightly grazed by cattle. The SAM-12 property has a mix of tall dense reed canarygrass with an area that is mowed to the water in the middle of the parcel. The frogs used the mowed area for egg deposition. On property SAM-8, about 1 km (.6 mi.) south of SAM-12, the upper Samish flows through a hay field adjacent to a large wetland complex. A spring-fed wetland, that had not been mowed or grazed in recent years, also occurs on the property. The egg masses were found in the spring-fed wetland. Both wetlands are dominated by reed canarygrass and common rush (*Juncus effusus*).

To the south about 3 km (1.9 mi.) from SAM-8, egg masses were found on a former dairy farm that is no longer grazed (SAM-7). The Samish River flows through the property. A clogged drainage pipe caused the property to flood resulting in a shallow, reed canarygrass dominated wetland where the Oregon Spotted Frog egg masses were found.

Black River population complex. Oregon Spotted Frogs occupy approximately 394 ha (974 ac.) of wetland over an area of approximately 27 sq. km (17 sq. mi.) in the upper Black River drainage in Thurston County (Fig. 18). The Black River starts at the south end of Black Lake. Historically the lake drained south into the river. In 1922, Black Lake Ditch was constructed at the north end of the lake to drain wetlands around Black Lake. This ditch was deepened in 1952 and 1976. In the 1960s, a pipeline crossing was constructed across the Black River south of Black Lake and north of Dempsey Creek. Spoils from construction were left in the stream and this combined with vegetation growth and beaver activity reversed stream flow from the Pipeline to the north starting in the 1980s (Smith and Wenger 2001). The first nine river miles south of the lake are extremely low gradient. In this area, the river flows through wetlands and bogs. Also, four major and two minor tributaries enter the river in this span. Listed in order from north to south, these creek tributaries are Dempsey, Salmon, Blooms Ditch, Beaver, Waddell and Mima. Oregon Spotted Frog occurrences within these tributaries and along the Black River flood plain are patchy and appear to be isolated from each other. To date, no occurrences have been found in Waddle or Mima creek drainages but additional surveys would be needed before their absence could be confirmed.

Dempsey Creek. The area known to be occupied by Oregon Spotted Frogs is about 123 ha (304 ac.). Dempsey Creek and its associated ephemeral tributaries provide aquatic connectivity between the seasonally flooded breeding areas and the permanent waters of the main wetland basin. The upper reaches of Dempsey Creek flow through lands that have been channelized and drained for pasture. During the wet season, portions of these pastures are inundated and hold water until summer providing the main breeding habitat within the drainage. Reed canarygrass dominates the wet pasture vegetation. The wetland basin is dominated by short, native, emergent vegetation and reed canarygrass. At mid-drainage, the wetland community transitions into shrub-dominated hardhack and willow wetland with forested uplands. At the confluence with the Black River (The Pipeline site), the wetland habitat is primarily shrub-scrub wetland.

Breeding activity in the upper watershed is concentrated into about fifteen localized areas including three on The Dairy Farm, one on the Musgrove parcel and eleven on The Forbes property. Some breeding pools were used every year while others were used primarily in years of higher or lower water conditions. Two breeding pools on The Forbes that were used regularly from 1996- 2006 appear to have been abandoned likely due to changes in vegetation density and height. The pastures were heavily grazed until 2006 when the dairy farm ceased operation. Cattle have been slowly re-introduced to the upper drainage starting at The Forbes in 2008, Musgrove in 2009, and The Dairy Farm in 2011. A few rural residential home sites are present as well as barns and other buildings associated with dairy farming. Beaver are present in the drainage but play a significant ecological role only in the lower drainage and along the Black River (i.e., The Pipeline site). The habitat in The Pipeline area is unusual for Oregon Spotted Frogs. The Black River in that area is slow flowing, in part due to beaver dams, and bounded by swampy habitat dominated by alders, hardhack and other shrubby species that grow on sedge hummocks. The frogs breed in shallow water openings in the swampy habitat (Fig. 15). Uplands along the lower drainage are managed mixed conifer-hardwood forest dominated by Douglas-fir (*Pseudotsuga menziesii*)/red cedar/red alder/big leaf maple.

Salmon Creek. The area known to be occupied by Oregon Spotted Frogs is 5 ha (12 ac.). The frogs occupy a small wetland on Salmon Creek that has a past and recent history of habitat alteration and hydrological manipulation. These alterations include excavation of a canal to drain land north of the current wetland, ponds excavated adjacent to the wetland (ca. 2008) and construction of a primitive road that bisects the original wetland area. In recent years, the site has also been colonized by beaver whose activities have resulted in expansion of the wetland into upland habitat. In addition, the beaver are removing portions of the road resulting in increased water flow and connectivity. Colonization by Oregon Spotted Frogs may be associated with the more recent habitat modifications (K. McAllister, pers. comm.). It likely also indicates other Oregon Spotted Frog occurrences in the watershed. The entire drainage is in private ownership, mainly residential.

Blooms Ditch (110th). Oregon Spotted Frogs have not laid eggs on this property since 2005. The area known to have been occupied by Oregon Spotted Frogs was 12 ha (30 ac.). Blooms Ditch flows through this property and is surrounded by wetland habitat completely overgrown by dense thatched reed canarygrass. The grass has excluded most of the native vegetation and left little open water habitat even at high water. Shrub-wetland habitat is also present at the site. The frogs were discovered after a co-operative restoration effort between USFWS and Natural Resources Conservation Service (NRCS) that excavated deeper areas that would hold water through summer, scraped 1–3 acres of reed canarygrass and planted shrubs in the uplands. The restoration effort resulted in suitable Oregon Spotted Frog habitat for about four years before reed canarygrass completely overgrew the site.

Black River Floodplain (123rd). The area known to be occupied by Oregon Spotted Frogs is 38 ha (94 ac.). Wetland habitats include seasonally flooded former pasture lands, emergent wetland, scrub-shrub wetlands and riparian habitat. This site was used for agriculture, including cattle grazing, until around 1999. Current ownership is USFWS Nisqually National Wildlife Refuge. The site is managed primarily for the Oregon Spotted Frog. In 2000-2001, the refuge, in cooperation with NRCS, enhanced 15 acres of habitat by removing reed canarygrass thatch and excavating areas to provide surface water in dry years (USFWS 2009, M. Bailey, pers. comm.). Reed canarygrass dominated areas were excavated to a level that would support spikerush (*Eleocharis*)-dominated community and was then seeded with native wetland seeds collected from the parcel. Small areas less than a quarter acre were excavated one to two feet deeper to hold water throughout the summer. The restoration also included connecting the wetland to the Black River via an abandoned ditch. The restoration efforts provided suitable oviposition habitat for a number of years but the area is once again overgrown by reed canarygrass. As of 2011, fall mowing was required to create suitable spring oviposition habitat in most areas (M. Bailey, pers. comm.).

Allen Creek (and Blooms Ditch). The area known to be occupied by Oregon Spotted Frogs is 62 ha (153 ac.). Wetland habitats include seasonally flooded pasture lands, emergent wetland, scrub-shrub wetlands and riparian habitat. At high water, including during the Oregon Spotted Frog breeding season, waters from Blooms Ditch intermingle with those of Allen Creek. This site is in private ownership. Cattle grazing and rural residential development are the main land uses in the area.

Beaver Creek (and Allen Creek headwaters). The area known to be occupied by Oregon Spotted Frogs is about 148 ha (366 ac.). The eastern end of the wetland is fed by a tributary of Beaver Creek and the western end is the headwaters to Allen Creek via Deep Lake and Scott Lake. Consequently Beaver and Allen creeks occupy a common portion of the wetland and the wetland is continuous between the two streams. Allen Creek is also a tributary to Beaver Creek, entering Beaver Creek approximately 8.5 km downstream from the Allen Creek headwaters. Hydrology at the site was altered in the past for agricultural use that included wetland draining and channelization. Habitat includes seasonally flooded former pasture lands dominated by reed canarygrass on the west end and a mixed reed-canarygrass/willow dominated wetland toward the east end. These two areas are separated by a mosaic of deeper water wetland and riparian habitat. Upland habitat surrounding the area includes mounded prairie/oak woodland-/wetland mosaic, a former explosives storage depot and rural residential development (McAllister and White 2001). Beaver are present but have played a limited ecological role at this site in recent years. WDFW owns the lands known to be occupied by Oregon Spotted Frogs, the West Rocky Prairie Management Unit, where habitat management includes the needs of the frogs.

East Cascades Ecoregion

Trout Lake population complex. The entire Trout Lake Creek watershed covers approximately 19,425 ha (48,000 ac.) ranging in elevation from 597–1,806 m (1,960–5,925 ft.) above sea level. The headwaters are the southern slopes of Mount Adams. The area known to be occupied by Oregon Spotted Frogs is approximately 469 ha (1,160 ac.) of the lower Trout Lake Creek watershed (Fig. 21) in Skamania and Klickitat counties.

Oregon Spotted Frogs occur mainly in the extensive palustrine wetland and riparian system within the 6000 year-old Trout Lake lakebed. Wetland types include riparian, forested, scrub-shrub, emergent, emergent/scrub-shrub, aquatic bed wetlands, and seasonally flooded former pasture lands. Beaver play a significant environmental role within the watershed. The surrounding uplands are pasture, ponderosa pine (*Pinus ponderosa*) - Douglas-fir (*Pseudotsuga menziesii*) forest, rural residential and a developed campground.

Major human-caused alterations to the wetland began when settlers started moving to Trout Lake Valley in the 1880s (USDA Forest Service 1996, Napp 2001). The legacy of irrigation ditches and canals continues to impact the hydrology of the wetland. Fire suppression started in 1910. Timber harvest on national forest lands began in the 1940s with large harvests in the 1970s and 1980s. State and privately owned timber lands are also present in the valley. Today, approximately one third of the watershed is in hydrologically immature vegetation (i.e., vegetation that is less able to retain and slowly release water). Mature trees have been logged from Trout Lake (wetland) more than once. Dense road construction in the watershed has increased sediment movement toward streams and tractor logging has compacted soil, inhibiting water filtration into soil and promoting further surface erosion. Increased sediment loads from these activities may be hastening eutrophication of Trout Lake wetland. A long history of livestock grazing has resulted in areas of soil compaction and creek bank erosion (Napp 2001). The soils at Trout Lake are sensitive to compaction and this compaction inhibits or destroys the capacity of the soil to hold water. This has direct impacts on quality, type and amount of vegetation and the protection that vegetation provides to the soil. Areas of impact were identified especially on the northern and eastern sections of the wetland. Cattle paths in the northern area were also noted and indicated as problematic in having the ability to change hydrology of an area by creating water conveyance channels away from the wetland.

The lower drainage of Trout Lake Creek changed direction starting in the early 1960s due to a log dam (Napp 2001). By 1977, Trout Lake Creek had fully changed its course. It is not clear as to whether this was due to indirect or direct effects of human activity. The flooding of agricultural fields created emergent wetlands that provide important breeding areas on the west side of the wetland. The change in creek channel dramatically lowered the amount of water in the original stream channel, altered the location of water in the wetland and likely increased the rate of sedimentation into the wetland including hastening the succession of Trout Lake into emergent wetland (Napp 2001). The new channel is also different from the old channel in being straighter, wider and deeper, all of which have potential to alter the habitat (i.e., more evaporation, fast water flow, altered flooding regime). A more minor alteration to the wetland was the construction of a small pond on the western side of the site. The pond has connectivity to Trout Lake Creek and Oregon Spotted Frogs use the pond in summer and fall (Hallock and Pearson 2001).

Trout Lake Creek upstream from Trout Lake wetland was altered following flood events in 1959. According to Napp (2001), large wood was removed and levees constructed within the active stream channel to facilitate stream conveyance. In some cases this was done with a bulldozer to push wood and gravel out of the creek and up onto its banks. In another section, riparian habitat adjacent to Trout Lake Creek was modified into ponds. A small number of Oregon Spotted Frog egg masses may have been found along these human-modified ponds in the past but these observations went undocumented and egg masses were not found during surveys in 2011 (L. Hallock, pers. ob.). The creek reach near the national forest boundary was widened by approximately 50% between 1967 and 1989. The flood of 1996 further exacerbated the widening of the channel (USDA Forest Service 1996). Oregon Spotted Frogs occupy ponds in the floodplain adjacent to this area of the creek channel in habitat that was altered by humans at some point.

Some issues regarding connectivity are not well understood. Within the main wetland, most areas are inundated to some extent during the spring. It is assumed that frogs can move freely throughout the entire wetland during this time. After spring waters retreat, the uplands along the old Trout Lake Creek channel create a terrestrial barrier between the eastern and western marshes. The Oregon Spotted Frog occurrences in ponds upstream from Trout Lake wetland are likely isolated to some extent from most of the population by the distance (> 4 km creek distance) between these sites but no aquatic barrier that would prevent movement up and down the watershed by frogs is known to occur.

Conboy Lake population complex. The Conboy Lake wetland complex, in the Glenwood Valley southwest of Mt. Adams at an elevation range of 550–561 m (1,804–1,840 ft.), encompasses two lakebeds that are typically entirely seasonal except in wet years (Hayes et al. 2000). The larger is Camas Prairie to the west and the smaller is Conboy Lake to the east. These are joined by Outlet Creek and canals that are the main drainage ways for the system that flows northeast into the Klickitat River. The extent of wetland habitat occupied by Oregon Spotted Frogs at high water is approximately 2,968 ha (7,335 ac.; Fig. 23).

Based on Cowardin et al. (1979), more than 95% of this wetland complex is palustrine dominated by reed canarygrass and native wetland grasses, sedges, rushes and forbs (Hayes et al. 2001). Much of the ephemeral wetlands are used as cattle pasture or hayed during the dry season to control reed canarygrass and maintain short-grass habitat suitable for Oregon Spotted Frogs, Sandhill Cranes and waterfowl (S. Ludwig, pers. comm.). Four creeks, an extensive canal system and springs comprise most of the perennial water habitat at the site. Stands of aspen and alder occur in patches either in or along some margins of the lakebed along with scattered cottonwoods. The area is located at the transition between more mesic Douglas-fir dominated forests and drier Ponderosa pine-dominated forests, with the latter dominating the uplands surrounding Conboy Lake. Some areas of dense lodgepole pine (*Pinus contorta*) also occur. The adjacent lands in private ownership are managed for forestry and agriculture (USFWS 2002b). Development surrounding the wetland complex is low density rural housing and ranches.

Roughly two-thirds of Oregon Spotted Frog-occupied habitat at Conboy Lake is protected within the 2,599-ha (6,423 ac) Conboy Lake National Wildlife Refuge (hereafter the Refuge) managed by USFWS. The Refuge was established in 1964 to provide habitat for migratory birds including ducks and geese. The initial lands were acquired through governmental condemnation and consequently may have an influence on local perspectives about the refuge and, in turn, Oregon Spotted Frogs. Spotted frogs occur on private lands surrounding the Refuge but little is known about these occurrences. Management on private lands (e.g., draining for better hay production, removal of beaver dams) can change water levels and flow conditions which may conflict with the Refuge's water management requirements for Oregon Spotted Frogs and other wildlife.

Major alterations to the Conboy Lake wetland complex began when settlers started moving to Glenwood Valley in the late 1800s. Wet meadows were drained through a series of canals, ditches and dikes, largely developed during the interval 1910-1912 to increase hay production. Creeks flowing into this wetland complex were also altered and today are entirely channelized within the wetland complex. These include five named creeks: Chapman and Holmes drain the low hills to the south and southwest; Bird and Frasier are snow fed from the slopes of Mt. Adams, and Bacon Creek provides hydrological inputs in the northeast area of the refuge (M. Hayes and S. Ludwig, pers. comm.). Cold Springs Ditch, a constructed channel that draws from Bird Creek on the north side of the Refuge, follows the northwest margin of the main lakebed where it also gathers water from several moderate-volume coldwater springs before reaching Outlet Creek. These conveyance channels are 4–10 m (24.6–32.8 ft.) wide and total about 33 km (20.4 miles) in length. A small area of Bird Creek must be excavated every 2-3 years to maintain sufficient flow through the system due to the high bedload that is moved annually. Most of the other ditches have been cleaned on a much less frequent basis (up to 20 years) but in the future select reaches will be cleaned on a 5-10 year cycle (S. Ludwig, pers. comm.).

Ditching, filling, beaver dam removal and other habitat alterations have resulted in little or no retention of surface water in the late-season lakebeds. The historical Conboy lakebed likely retained water 10-12 months in most years. Currently it retains water only during wet years and is drained annually to control bullfrogs (S. Ludwig, pers. comm.). Camas Prairie retains water year-round over a small area in such years. The volume of Bird Creek has been artificially augmented since the 1930s with water from Bacon Creek via the Hell Roaring Ditch about 8 km (5 mi) north of the Refuge. In the late 1990s, beaver were removed from the canal system and are no longer allowed to create extensive plugs. Previous to this, beaver structures influenced water retention within the lake bed. Typically, aquatic habitat is reduced to about 400 ha (1,000 ac) during the late summer-early fall (Hayes et al. 2000), mostly due to water conveyance ditches and channels. After the seasonal lakebeds dry, the network of ditches and channels provide the only aquatic habitats for Oregon Spotted Frogs. The channels support vegetation including several pondweeds (mostly *Potamogeton natans*) that provide foraging and refuge habitat for the frogs.

Fire suppression started with Euro-American settlement in the late 1880s. Previous to that, local Native American Tribes including the Klickitat, Yakama, Cannikins and Interior Salish used fire to maintain the prairies for camas, to exclude dense underbrush and prevent encroachment by ponderosa pine (USFWS 2002b). After fire suppression was initiated, fires occurred mainly from lightning strikes. In 2002, USFWS implemented fire management guidelines including prescribed burn programs to maintain the prairies (USFWS 2002b). This is beneficial for the Oregon Spotted Frogs who require full sun-exposure and short vegetation for breeding habitat. Incidental fire suppression activities, however, have the potential to adversely impact Oregon Spotted Frogs because fires are suppressed with water from refuge canals and ditches, the only aquatic habitat available to the frogs during the summer and fall. Whether enough water would be withdrawn to actually impact the frog population is unknown.

At the establishment of the Refuge in 1964, lodgepole pine was absent from the Conboy Lake wetland complex (M. Hayes, pers. comm. based on discussion with former Refuge manager H. Cole). Lodgepole is now widespread and in some places occur in dense stands. Whether this expansion is due to fire suppression, reduced flooding, climate change or a combination is unclear. Grazing exclusion may also have played a role. Authorized grazing ended in the 1970s and many of the encroaching lodgepole pines are around 30 years old (S. Ludwig, pers. comm.). Of concern is the encroachment of lodgepole into Oregon Spotted Frog breeding habitat. As the trees mature, they will render the habitat unsuitable for oviposition. In response, USFWS has started removal of lodgepole in selected areas.

LEGAL STATUS

U.S. Federal. On April 19, 1997, the USFWS found listing the Oregon Spotted Frog as threatened or endangered was warranted but precluded by other higher priority listing actions (USFWS 2009). On May 10, 2011, the Oregon Spotted Frog was one of the candidate species identified in the settlement agreement between the U.S. Fish and Wildlife Service and WildEarth Guardians that laid out a 6-year work plan to review and address the needs of more than 250 candidate species to determine if they should be added to the Federal List of Endangered and Threatened Wildlife and Plants. The status review of the Oregon Spotted Frog is scheduled to be completed by September 30, 2013. A USFWS species proposed for listing receives some level of protection on federal lands including national wildlife refuges. The species is listed on the Oregon BLM Special Status Species List and on the Forest Service Regional 6 Regional Forester's Sensitive Animal List. As such, BLM and Forest Service are subject to laws, regulations and land management applicable to their agencies that address protection of sensitive, candidate and federally listed species and their habitats. Specifically, management must not result in loss of species viability or create significant trends toward federal listing (FSM 2670.32) for any sensitive species.

Washington. The Oregon Spotted Frog was listed as State Endangered in 1997 (WAC 232-12-014). It is unlawful to hunt, fish, posses, maliciously harass or kill endangered species or maliciously destroy the nests or eggs of endangered fish and wildlife (RCW 77.15.120). Oregon Spotted Frogs may not be collected, harassed, possessed (live or dead), or sold except by special permit

Oregon. Oregon Spotted Frogs are given a "Critically Sensitive" species classification under Oregon's Sensitive Species Rule (OAR 635-100-040). The Sensitive Species List is primarily a non-regulatory tool to focus wildlife management and research activities to prevent species from declining to the point of qualifying as threatened or endangered.

California. Oregon Spotted Frogs are designated as California Species of Special Concern, an administrative designation that carries no formal legal status.

Canada. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated the Oregon Spotted Frog as Endangered in an emergency assessment on 13 September 1999. The status was re-examined and confirmed May 2000 (Haycock 2000). It is also protected under the British Columbia *Wildlife Act*, a regulatory act that prohibits all activities that could be harmful to a listed species and its habitat (http://www.env.gov.bc.ca/wld/frogwatch/whoswho/factshts/orspot.htm, accessed February 24, 2010).

MANAGEMENT ACTIVITIES IN WASHINGTON

Species monitoring. The Black River egg mass census has been conducted since 1996 by WDFW, USFWS and Port Blakely Tree Farms. The Trout Lake census has been conducted by Department of Natural Resources and WDFW since 1997. U.S. Forest Service started monitoring the Oregon Spotted Frog site within Gifford-Pinchot National Forest, Skamania County, in 2008. The Conboy Lake census has been conducted by USFWS and WDFW.

Species inventory. Surveys to find undocumented Spotted Frog populations in Washington started in 1990 and have continued to present (McAllister and Leonard 1990, Gilbert et al. 1991, McAllister and Leonard 1991, McAllister et al. 1993, Adams 1996, Leonard 1997, Hallock and Leonard 1997, Watson et al. 2000, McAllister and Walker 2003, McAllister et al. 2004a, Hallock 2009, Hallock 2012 and efforts by J. Engler, L. Hallock, M. Hayes, K. McAllister, M. Tirhi, T. Schmidt, S. Freed and B. Blessing). These efforts focused primarily on areas occupied historically and on public lands. The results expanded the known occupied areas for the Black River, Trout Lake and Conboy Lake population complexes but did not result in finding any additional populations. Other major amphibian survey efforts also did not find evidence of Oregon Spotted Frog persistence. The results of these surveys have reinforced the impression that Oregon Spotted Frogs are no longer present in most of the historical Washington range.

In 2011 and 2012, WDFW collaborated with the U.S. Forest Service and Seattle City Light to initiate Oregon Spotted Frog egg mass surveys in Whatcom and Skagit counties and were successful in finding eggs in the Sumas River, Black Slough and Samish Rivers (Bohannon et al 2012). The discovery of Oregon Spotted Frogs in drainages that were not documented historically raises hope that additional populations may persist on private lands.

Population reintroduction. A pilot reintroduction project was started on Joint Base Lewis-McChord Military Reservation at Dailman Lake in Pierce County in 2008.

Protection, enhancement and management of significant habitat. Many partners have worked together to protect Oregon Spotted Frog habitat. WDFW acquired the West Rocky Prairie Wildlife Area in 2006. Capitol Land Trust was instrumental in securing these lands for purchase by WDFW. USFWS Nisqually National Wildlife Refuge acquired occupied habitat on Dempsey Creek and the floodplains of the Black River. In 2000–2001 the refuge removed large areas of reed canarygrass and restored the native plant community at Blooms Ditch (110th) and Black River Floodplain (123rd). At their Musgrove site, they created breeding habitat in 2008 by mowing and reintroducing cattle to control reed canarygrass. CNLM is enhancing and restoring wetlands on a Nature Conservancy owned parcel in the Mima Creek drainage for potential Oregon Spotted Frog colonization or translocation. The most extensive habitat for the

Oregon Spotted Frogs on Dempsey Creek is owned by Port Blakely Tree Farms. In addition to critical oviposition habitat, their property provides the primary area of suitable summer and winter habitat in the drainage. Suitable habitat conditions in the oviposition areas are maintained by cattle grazing. In 2011, WDFW, USFWS and the private landowner of the Salmon Creek site initiated a cooperative habitat restoration effort. The project is focused mainly on reducing reed canarygrass.

Figure 25. 'Cut and Cover' treatment plot at Trout Lake.

The Trout Lake NAP was established in 1996 primarily for protection of the Oregon Spotted Frog population that occupies the site. Since its creation, WDNR's Natural Areas and Natural Heritage programs have worked together to acquire most of the parcels within the Trout Lake Creek watershed in Klickitat County. WDNR has acquired 716 ha (1773 acres) with grants awarded primarily from Washington Wildlife Recreation Program and also from The North American Wetlands Conservation Act. The Trout Lake Natural Area management plan was developed in 2001 (Washington Department of Natural Resources 2001). Under this plan, smaller irrigation ditches in the northeastern area of the preserve will be filled or blocked unless they provide important habitat for Oregon Spotted Frogs (D. Wilderman, pers. comm.). Alterations to the main canal, including installation of a water control structure, were made in 2005 with the goal of holding water longer to prolong the flooding period and reduce the rapid drawdowns in the eastern area of the wetland (D. Wilderman, pers. comm.). Livestock grazing was discontinued within the preserve boundaries based on recommendations by Napp (2001) and an assessment of livestock grazing as a management tool to control reed canarygrass (Wilderman and Hallock 2004). The cattle had a negative impact on habitat and did not provide a clear benefit to the spotted frog population. Observed negative impacts included excessive browsing of shrubs, particularly willows, and impacts to streambank stability. Other management alternatives were recommended for managing reed canarygrass. As of 2009, 'cut and cover' efforts were underway to manage reed canarygrass by covering dense growth patches with landscape cloth and replanting these areas with low growing native wetland species (Fig. 25; D. Wilderman and K. Bugner, pers. comm.). In 2012, the western breeding areas were mowed and this is likely to be incorporated in site management for those areas (D. Wilderman, pers. comm.).

Habitat management by the USFWS at Conboy Lake NWR has included several considerations for the Oregon Spotted Frog. Mowing and haying are used to manage reed canarygrass and enhance oviposition habitat. Improvements to the water control systems have been made since 2001 to achieve better management of water levels especially during the oviposition period. Bio-swales were created between conveyance channels and the lakebed to facilitate movement of frogs between overwintering and breeding habitat. Efforts are underway to set back succession in areas used for breeding by removing encroaching lodgepole pines and conducting prescribed burns.

Whatcom Land Trust owns the headwaters of the Samish River as part of the Samish River Preserve. Their parcels (SAM-2 & 6, Fig. 17) are under NRCS contract for salmon habitat enhancement. Both the land trust and NRCS are working with WDFW to determine how to proceed to best enhance habitat for both salmon and Oregon Spotted Frogs.

Research to facilitate and enhance recovery. WDFW, in cooperation with Port Blakely Tree Farms, studied the Oregon Spotted Frogs along Dempsey Creek from 1996-2006 (Leonard et al. 1997a&b, Watson et al. 1998, 2000, 2003). Washington Department of Transportation provided funding in 2000-2001 to study overwintering and oviposition habitat use (McAllister and White 2001, Hayes et al. 2000, Hallock and Pearson 2001, Hayes et al. 2001, Risenhoover et al. 2001a, 2001b). Kapust et al. (2012; *see also* White 2002) removed reed canarygrass from study plots and determined that Oregon Spotted Frogs would select such plots for egg deposition. In 2009, WDFW initiated research similar to Kapust et al. (2012) but on a larger scale with the addition of a burning treatment. Port Blakely Tree Farms initiated a study in 2009 investigating cattle grazing impacts to oviposition habitat using fencing exclosures to evaluate pre- and post- grazing changes; a somewhat parallel effort was initiated on the adjacent USFWS-owned Musgrove Property (Bailey 2011). Department of Natural Resources' Natural Areas Program conducted a prescribed grazing assessment at Trout Lake (Wilderman and Hallock 2004). Pearl et al. (2007) took skin swabs from Oregon Spotted Frogs that inhabit Black River and Trout Lake as part of an assessment of chytrid fungal pathogen prevalence in Pacific Northwest anurans.

In 2009, a study was initiated to determine Oregon Spotted Frog sensitivity to the amphibian chytrid fungal pathogen (Padgett-Flohr and Hayes 2011). In 2010, Washington Department of Ecology provided funding to the Co-operative Fish and Wildlife Service Unit at the University of Washington, in cooperation with WDFW, to conduct an experiment to determine if exposure to the herbicide-surfactant combination Imazapyr-Agridex had toxicity effects on juvenile Oregon Spotted Frogs. Initial experiments found no mortality or sublethal effects on juvenile Oregon Spotted Frogs exposed to the herbicide-surfactant combination; however, additional research will be needed to make sure this mix is not toxic to other aquatic organisms and does not have any long-term impacts on Oregon Spotted Frogs (Yahnke et al. 2013). In related work, WDFW initiated a study in 2010 of amphibian phenology at the Beaver Creek site to determine which life stages would be exposed if herbicides were used to control reed canarygrass. Oregon Zoo, WDFW, and Kyle Tidwell cooperated on a study of the anti-predator behavior of Oregon Spotted Frogs from Black River and Conboy Lake from 2009-2011 (M. Hayes, pers. comm.).

Information management systems and sharing. WDFW Wildlife Surveys and Data Management unit (WSDM) is the main repository for Oregon Spotted Frog data collected in Washington. The WSDM unit also compiles annual egg mass census data. WSDM and Washington Department of Natural Resources' Natural Heritage Program worked together in 2007 to map the habitat occupied by Oregon Spotted Frogs at Dempsey Creek and Trout Lake (Element Occurrences or "EOs"). The EOs are maintained by the Heritage Program in cooperation with WSDM.

Public information and education programs. In the late 1990s, WDFW produced a pamphlet titled "Frogs…Red-legged, Spotted & Cascades" to provide information on identification of Washington's native ranid frogs. Conboy Lake National Wildlife Refuge supplies a refuge brochure that identifies and provides general and management information on Oregon Spotted Frogs (S. Ludwig, pers. comm.).

The Washington Herp Atlas (http://www1.dnr.wa.gov/nhp/refdesk/herp/), a cooperative project of the WDNR, Bureau of Land Management, WDFW, and U.S. Forest Service, was created in 2005. It provides current information on Washington's amphibians and reptiles and is designed for outreach to biologists and the public. The species account for the Oregon Spotted Frog features descriptions, identification tips, habitat information and photographs. The photographs include a variety of life stages, typical habitat and a set of annotated photographs with key identification features indicated. In addition, threats, management concerns, inventory and research needs are listed. The species accounts are updated as funding becomes available. The last update for Oregon Spotted Frog species account was in 2005 but the distribution map was updated in 2011 to reflect the populations found in Whatcom County.

In 2003, Leaping Media produced a six minute video featuring field work on Oregon Spotted Frogs at the Pipeline site on the Black River (http://www.leapingmedia.com/Rana.html). The research featured was important in establishing the connectivity of the Oregon Spotted Frogs occurring in the upper and lower Dempsey Creek drainage (McAllister and Walker 2003). The video segment was part of The Frog Project with topics ranging from whimsical examinations of frogs in culture to firsthand accounts from scientists.

In 2008, the Northwest Zoo and Aquarium Alliance celebrated *The Year of the Frog* by addressing the global amphibian decline. Northwest Trek, Oregon Zoo, Woodland Park Zoo and Pt. Defiance Zoo and Aquarium featured stories about Oregon Spotted Frog conservation and highlighted recovery efforts on their webpages. Press releases were also produced by some of the institutions. Northwest Trek featured stories about recovery efforts in their quarterly publication *Trek Tracks* and had a fund raiser selling paper frogs. The Pt. Defiance Zoo and Aquarium website highlighted conservation projects they funded including Oregon Spotted Frog and prairie habitat enhancement, Oregon Spotted Frog post-release telemetry and Oregon Spotted Frog reintroduction review. The Oregon Zoo developed a series of short videos including: *Meet Oregon Spotted Frogs Captain Kirk, Scotty and Spock!*; *Threatened Frogs Released Into The Wild*; *Spotted Frog Tadpoles at the Oregon Zoo*; *Oregon Spotted Frogs and Tadpoles;* and *Spotted Frog Headstart Program*. The Woodland Park Zoo produced a short video, *Frogs Gone Wild!* Woodland Park Zoo and Mountain View Conservation and Breeding Center outreach resulted in the FROGBOX highlighting the Oregon Spotted Frog on their website. WDFW produced press releases regarding the recovery and release activities.

Coordination and partnership. Several government agencies, private land owners and conservation groups coordinate on annual egg mass censuses. More specifically, the Black River egg mass census is a cooperative effort of WDFW, USFWS Nisqually National Wildlife Refuge, and Port Blakely Tree Farms. Washington Natural Heritage Program (WDNR) also contributed towards these efforts 1996-2009. The Nature Conservancy has participated since 2008. The Trout Lake egg mass census is a cooperative effort of WDNRs Natural Heritage and Natural Areas programs, and WDFW, with additional assistance from US Fish and Wildlife Service. The Conboy Lake egg mass census is a cooperative effort of WDFW, U.S. Fish and Wildlife Service, and Conboy Lake National Wildlife Refuge with a large citizen science volunteer effort. The Oregon Zoo provided the majority of volunteers toward the Conboy survey effort. The Skagit and Whatcom survey effort in 2011 and 2012 involved a collaboration of WDFW, U.S. Forest Service, Seattle City Light, the Whatcom and Skagit Land Trusts, The Nature Conservancy, and numerous private landowners and volunteers. The effort was backed by funding from a U.S. Fish and Wildlife Service species recovery grant. The Whatcom Conservation District greatly facilitated access to private land and led surveyors to the first documented egg mass cluster in Whatcom County.

The Nature Conservancy and the Capitol Land Trust were instrumental in securing Oregon Spotted Frog occupied lands for state purchase in the Black River watershed. The Nature Conservancy was instrumental in securing Oregon Spotted Frog occupied lands for state purchase at Trout Lake. Columbia Land Trust and Department of Natural Resources, among others, were partners on the North American Wetland Conservation Act grant that funded recent habitat restoration work at Trout Lake. The National Resources Conservation Service (NRCS) also provided funding for habitat restoration work at Trout Lake. The Washington Oregon Spotted Frog Working Group was initiated in 2008. Members include biologists from state and federal agencies, Port Blakely Tree Farms, Joint Base Lewis-McChord, Center for Natural Lands Management, and The Evergreen State College. Also participating are members of the Northwest Zoo and Aquarium Alliance including staff from Point Defiance Zoo and Aquarium, Mountain View Conservation and Breeding Center, Woodland Park Zoo, Northwest Trek, and Oregon Zoo.

Many entities are involved with the Oregon Spotted Frog reintroduction project on Joint Base Lewis-McChord. The Washington Oregon Spotted Frog Working Group was formed to consult on various aspects of the project. Northwest Zoo and Aquarium Alliance is a significant partner with members participating in recovery teams, captive rearing, outreach and education programs, and research. More specifically, Point Defiance Zoo and Aquarium provides financial and facilitation support. Woodland Park Zoo, Northwest Trek, and Oregon Zoo are raising Oregon Spotted Frogs from eggs to metamorphosis. Two Cedar Creek inmates raised frogs in 2009-2012 as part of a partnership between The Evergreen State College and Washington Department of Corrections' Sustainable Prison Project that allows prisoners to participate in science-based conservation projects. Biologists from Joint base Lewis-McChord and WDFW monitor the released frogs. Oregon Zoo's Future for Wildlife Fund and Point Defiance Zoo and Aquarium Conservation Committee granted funding for research projects related to the captive reared and released frogs.

FACTORS AFFECTING CONTINUED EXISTENCE

The primary factors affecting the continued existence of Oregon Spotted Frogs in Washington are related to habitat loss and degradation coupled with the precarious nature of geographically isolated populations. The legacy of historical changes to riparian and wetland habitat, combined with introduction of invasive, non-native flora and fauna, continues to impact Oregon Spotted Frog populations. In recent years, new threats have emerged including new diseases and predicted climate changes that have the potential to devastate amphibian populations (Wake and Vredenburg 2008).

The population decline of Oregon Spotted Frogs is part of a world-wide amphibian decline (Barinaga 1990, Wake and Morowitz 1991, Corn 1994, Green 1997, Stuart et al. 2004). In the western states, true toads (bufonids) and true frogs (ranids) have been most affected (Wells 2007). The same amphibian characteristics that have made these species successful in their evolutionary past now, paradoxically, make them susceptible to current environmental degradation. These traits include small body size, ectothermic physiology ("cold-blooded"), highly permeable skin, dependency on moist habitats, cutaneous respiration, complex life cycles, small geographic ranges, and limited dispersal ability (Duellman and Trueb 1986, Wells 2007, Wake and Vredenburg 2008). Understanding amphibian vulnerabilities, as well as those specific to Oregon Spotted Frogs, is crucial in achieving recovery.

The decline in the occurrence and population sizes of Oregon Spotted Frogs is attributable to several major human-caused stressors. These include:

- Wetland loss and alteration.
- Loss of disturbance processes that set back succession
- Introduction of non-native/invasive flora and fauna (e.g., reed canarygrass, bullfrogs, game fish).
- Alteration of creek and river channels.

Oregon Spotted Frogs have specific life history traits, habitat requirements, and population characteristics that limit their distribution and make them vulnerable to these changes. These include:

- A completely aquatic life history.
- Communal reproduction concentrated on the landscape with the same localized breeding areas used annually.
- High levels of population fluctuation.
- Dispersal limited to aquatic corridors.
- Association with relatively large permanent wetlands (typically > 4 ha) that include shallow, warm-water habitats.
- Breeding habitats that have shallow water (≤ 30 cm), short vegetation, and full sun exposure with relatively stable hydrology and aquatic connectivity to permanent waters.
- Overwintering habitats that provide adequately oxygenated water and shelter from freezing conditions and predators.

Additional threats include the geographic isolation of Oregon Spotted Frog populations and the increase of water-borne pollutants and diseases. This list of threats is neither exhaustive nor independent, as a number of factors are interconnected. Climate change is a looming concern because it involves potential changes likely to have severe effects on Oregon Spotted Frogs across their geographic range.

Adequacy of Existing Regulatory Mechanism

As a State Endangered species (WAC 232-12-014), Oregon Spotted Frogs may not be collected, harassed, possessed (live or dead), or sold except by special permit. A number of regulations help protect the wetland habitats of Oregon Spotted Frogs. Two state laws, the State Water Pollution Control Act (RCW 90.48.020) and the Shoreline Management Act (RCW 90.58), give the Washington Department of Ecology the authority to regulate wetlands. Ecology also uses the State Environmental Policy Act (SEPA) process to identify potential wetland-related concerns early in the permitting process. A WDFW permit approval (Hydraulic Project Approval or HPA) is required for projects that change the natural bed or flow of any state waters. Additional regulations in Washington that provide some protection for wetlands include local zoning and critical area ordinances and Washington State's 1990 Growth Management Act (GMA; RCW 36.70A and its amendments). Local regulations created under GMA, and their implementation, vary widely across the state. Two major federal acts that protect wetland habitats include the 1972 Clean Water Act (CWA; Sections 401 and 404) and Section 10 of the Rivers and Harbors Act. These are implemented by the U.S. Army Corps of Engineers.

Of particular concern for Oregon Spotted Frogs is that these regulations do not require any maintenance of short vegetation structure (e.g. early seral vegetation) in seasonally flooded wetland habitats on the periphery of perennial wetlands. Rather, woody plantings are encouraged for restoration and mitigation to restore native vegetation, reduce water temperatures, shade reed canarygrass and so forth. Also, some land management activities that could degrade habitat for Oregon Spotted Frogs are exempt from regulation. For example, the irrigation ditches and canals in the Glenwood Valley, including Conboy NWR, are the only habitats with sufficient water in late summer for the frogs. Management of these irrigation canals is one of the most significant habitat alterations that take place and these actions directly impact spotted frogs. These ditches and canals may fall under the CWA (Talent Decision as cited Washington State Department of Ecology et al. 2006) but even so, most routine maintenance activities are exempt under CWA 404 f. WDFW hydraulic code authority extends only to state waters (no federal lands, such as Conboy NWR, are covered) and is to protect fish and fish habitat from the impacts of hydraulic projects. Some ambiguity exists in determining if irrigation canals are state waters because only modified natural watercourses are covered. Further clarification by WDFW as to which irrigation canals were natural watercourses will provide the information needed to determine when HPAs are required.

WDFW requires a fish stocking permit to plant fish in ponds or lakes on private land in Washington. Species that are suggested for planting into private waters include Rainbow Trout, Largemouth Bass, Bluegill Sunfish, and Channel Catfish. The permit application requires a biological evaluation that is concerned primarily with an evaluation of the site to make sure that fish cannot escape into nearby waters and that the fish come from an approved source but does not take into account the potential impact to Oregon Spotted Frogs. Non-permitted stocking still occurs.

Bullfrogs are a Prohibited Aquatic Animal Species and may not be possessed, imported, purchased, sold, propagated, transported, or released into state waters (WAC 220-12-090, RCW 77.12.020). They are considered deleterious to the environment or wildlife of the state. This regulation helps prevent future introductions but little can be done to mitigate the impact of bullfrogs that are already well-established in the state.

Small Population Size, Isolation and Genetic Health

The Oregon Spotted Frog's existence is affected by isolation of remnant populations, small size of some populations, and fluctuations in breeding numbers that may typify this species. The remaining populations in Washington are isolated by distances that preclude any connection by natural dispersal (Blouin et al. 2010). Even within population complexes, barriers that inhibit or prevent dispersal may exist (McAllister and Walker 2003). Of critical concern are barriers that interfere with aquatic travel. Habitat modifications that block aquatic connectivity have been shown to fragment populations of the closely related Columbia Spotted Frog resulting in localized extinctions (Patla 1997, Patla and Peterson 1997). Larger, more broadly distributed populations tend to be more resilient whereas small populations are more vulnerable to environmental and demographic factors. Oregon Spotted Frogs invest all of their reproductive effort into limited areas where adverse environmental conditions or some calamity can have great effect (McAllister and White 2001). Hydrologic modifications are of particular concern because all aspects of the species aquatic life history may be affected (Hayes et al. 2000).

Limited dispersal ability is typical of most amphibian species. Small populations can persist for years in isolated patches of suitable habitat with relatively little impact on either population size or genetic structure of the population (Wells 2007). It is not unusual for an amphibian to exhibit low within population genetic diversity (Blouin et al. 2010). Through time, however, isolation and small population size have genetic consequences. Limited attention has thus far been given to the genetic health of Oregon Spotted Frog populations (but see Blouin 2000, Funk et al. 2008, Phillipsen et al. 2009, Blouin et al. 2010, Phillipsen et al. 2011). In general, Oregon Spotted Frogs have very low genetic diversity even for a ranid frog and this likely is related to their aquatic habits that limit dispersal to aquatic corridors (Blouin et al. 2010).

Blouin et al. (2010) identified six major genetic groups within the species. Four are more closely related and form the larger "northern" group including populations in British Columbia, Black River, Trout Lake-Conboy Lake, and Oregon's Camas Prairie. Within the Northern hierarchy, the British Columbia and Black River population clusters form the next natural grouping. The occurrences in Whatcom and Skagit counties have not been evaluated but likely also fall within this group. The Camas Prairie population in Wasco County, Oregon, is unique and appears to be the sole representative of a distinct genetic group that once existed in Oregon. The other two genetic groups are located in Oregon's central Cascades and Klamath Basin. Blouin et al. (2010) stressed that reproductive isolation pre-dates European influences.

The finding of Phillipsen et al. (2009) that Oregon Spotted Frogs at his study site had a monogamous mating system is significant for monitoring and species management. Their results support the use of egg mass counts as a cost-efficient method of monitoring that probably gives a reasonable estimate of the number of adults that breed in a given year. Based on their results, each egg mass in a given year represents a female and a male.

Effective population size (N_e) is a fundamental parameter in the theory and practice of conservation genetics. The effective population size (N_e) is the number of individuals in a population that contribute offspring to the next generation and is related to population viability. Estimates of effective number of breeders (N_b) or N_e in natural populations are usually much lower than the census population size, N. The reason N_e and N_b are lower than N is not entirely understood, but for most species N_e is lower due to uneven genetic contribution to the next generation; that is some adults produce fewer or no young that survive to reproduce. Phillipsen et al. (2009) made the first attempt to identify life history stages in Oregon Spotted Frogs where N_b is reduced. Microsatellite data were gathered from large samples of Oregon Spotted Frog adults, juveniles and eggs from a breeding site near Sunriver, Oregon. The genetic estimates were then compared to an egg mass count estimate of the number of breeding adults. Phillipsen et al. (2009) did not find evidence that N_b was reduced related to mortality between eggs and metamorphs based on samples collected in a single year. Habitat conditions in that year may have influenced the results and from a management context, the pattern definitely merits further investigation.

Blouin (2000) found low numbers of alleles per locus and low heterozygosities in each Oregon Spotted Frog population and had similar findings for Columbia Spotted Frogs. He concluded that small N_e sizes may be a natural feature of the biology of spotted frogs. His findings (and subsequent findings by Blouin et al. 2010 and Phillipsen et al. 2011) also suggest that low movement and/or substantial genetic drift occurs among populations of the species even in less-disturbed landscapes like the Cascades Lakes cluster in Oregon. Gene flow between Oregon Spotted Frog populations was extremely low beyond about 10 km and little evidence existed that "stepping stone migration" between populations was occurring (Blouin et al. 2010). Despite their greater isolation, the Dempsey Creek, Beaver Creek and Conboy Lake populations had higher genetic diversity than populations from the Central Cascades (Oregon) or Klamath Basin groups perhaps due to the larger population sizes at these lower elevation drainages compared to the montane populations in Oregon (Blouin et al. 2010).

Habitat Loss, Degraded Condition and Fragmentation

The biology of Oregon Spotted Frogs predisposes them to substantial population fragmentation, even in relatively undisturbed habitat (Blouin et al. 2010). This is due primarily to their highly aquatic nature (Blouin et al. 2010). Persistence across the landscape requires aquatic travel corridors to allow gene flow, dispersal, and colonization (Semlitsch 2000). Columbia Spotted Frog, sister species to Oregon Spotted Frog, was extirpated from areas of Yellowstone National Park due, at least in part, to habitat modifications that altered aquatic connectivity (Patla 1997, Patla and Peterson 1997). Oregon Spotted Frog subpopulations must also occur within relatively small distances from each other to maintain genetic exchange. Tracked frogs have not traveled much over 2.5 km (Forbes and Peterson 1999, McAllister and Walker 2003), and gene flow is extremely small beyond about 10 km (Blouin et al. 2010). Therefore, it is important to maintain suitable habitat between occupied areas for the establishment of small "stepping stone" populations that will provide connectivity.

Oregon Spotted Frogs require habitat disturbances to set back vegetation to early succession stages (Hayes 1997a, Pearl 1999, Haycock 2000, Pearl and Bury 2000, Watson et al. 2003). Under pre-Euro-American settlement conditions, these would have resulted from flood events, creek meandering, fires (lightning and burning by indigenous peoples) and beaver impoundments (McAllister and Leonard 1997). Management is needed to compensate for the loss of these natural processes or re-introduce them to systems.

Invasive flora. Invasive wetland species that alter wetland structure and function continue to affect Oregon Spotted Frog habitat. Reed canarygrass is present at all of Washington's Oregon Spotted Frog occupied sites and is the invasive plant of greatest concern due to the potential loss of Oregon Spotted Frog habitat from shading and impenetrable thatch. The grasses' high rate of transpiration and ability to outcompete native plant species also are of concern for spotted frog habitat. Long-term management solutions are essential to recovery of Oregon Spotted Frogs in Washington, especially at occurrences in the Puget Lowlands where reed canarygrass is especially problematic because there is no snow pack to compress it. At Conboy Lake, mowing or haying are necessary to keep the reed canarygrass in check. Existing management options are either ineffective or limited due to the potential sensitivity of amphibians to herbicide application (Relyea 2005a, b; see also Aquatic Pollutants).

Wetland and riparian restoration efforts. Wetland and riparian restoration efforts can inadvertently degrade Oregon Spotted Frog habitat by eliminating expanses of short-emergent vegetation with full sun exposure; a habitat feature critical for Oregon Spotted Frogs. Restoration efforts to restore riparian and wetland functioning by planting shrubs and trees are underway throughout Washington primarily with the goal of enhancing habitat for salmon recovery. Former agricultural lands, including pasture and seasonally flooded wetland edges, are targets for these efforts. The shrubs and trees reduce water temperature, enhance water quality and control shade-intolerant invasive reed canarygrass but also may eliminate suitable habitat for Oregon Spotted Frogs, especially oviposition habitat in seasonally flooded areas. Currently, wetland and riparian habitat restoration efforts funded by the National Resources Conservation Service (NRCS) are underway or have taken place on lands occupied by Oregon Spotted Frogs in the Black Slough, Samish River, Black River (Blooms Ditch and Black River Floodplain), and Trout Lake.

Livestock grazing. Livestock grazing has positive and negative impacts on Oregon Spotted Frog populations. The extant sites in Washington all have a history of grazing. Where reed canarygrass is invasive, livestock grazing provides an inexpensive way of maintaining suitable oviposition habitat. Grazing reduces biomass, height and seed production while hoof action breaks up the roots and reduces thatch. Livestock grazing also can reduce rates of vegetation succession. Under this scenario, grazing is a surrogate for some of the disturbance processes that no longer occur such as beaver damming. Watson et al. (2000) indicated that reed canarygrass would develop into a monocultural mat at upper Dempsey Creek if not for grazing and hoof action of cattle. This was well illustrated in 2006-2008 when cattle were removed from The Forbes site on Dempsey Creek. Reed canarygrass and a native species of bur-reed (*Sparganium*) increased dramatically in the ephemeral breeding pools and ephemeral stream that connected the breeding ponds to permanent water. At Licht's historical Oregon Spotted Frog study site in British Columbia, removal of livestock allowed the vegetation to succeed unimpaired. Haycock (2000) indicated that photographs taken at the time of Licht's study show the site was wet meadow covered predominately by bulrushes (*Juncus effusus*), sedges (*Carex* sp.) and buttercup (*Ranunculus* spp.). Without grazing, willow and hardhack became well established (Haycock 2000), and this change in vegetation cover is thought to have been one of the reasons for extirpation of Oregon Spotted Frogs at this site.

Use of heavy seasonal or yearlong cattle grazing can negatively impact ecological conditions. The environmental damage caused by overgrazing is well documented (Kauffman and Krueger 1984, Belsky et al. 1999). Cattle can affect stream channel morphology, shape, water quality, and soil structure. The resulting erosion can fill in downstream ponds and alter water temperature. The heavy loads of nutrients from cattle waste increase eutrophication. As a consequence, waters may become hypoxic under certain conditions during the summer or winter. It can also contribute to the spread of invasive plants including reed canarygrass, through seed transport and soil disturbance. Additionally, aquatic eutrophication can benefit the molluscan hosts of the amphibian parasite *Ribeiroia ondatrae* which causes limb deformities in amphibians (Johnson and Chase 2004). Watson et al. (2003) noted that overgrazing can result in unsuitable Oregon Spotted Frog habitat conditions by eliminating too much emergent vegetation. Heavy grazing by cattle has also been shown to reduce woody vegetation and, in turn, negatively affect beaver populations (Feldhamer et al. 2003). The degree of riparian habitat degradation is strongly related to grazing intensity and timing (e.g., management practices). As a result, caution is needed when making definitive conclusions about cattle grazing as a management tool for Oregon Spotted Frogs (Hayes 1995; Wood River site, Marty 2005). Research to determine best grazing practices will be important for management prescriptions that lead to species recovery.

Hydrology. On-going water-control issues at Conboy Lake threaten what was once the largest population of Oregon Spotted Frogs. Prior to 2001, the water control system at Conboy was no longer able to retain adequate water within the lakebed and the resulting instability of water levels contributed to a 77% breeding population loss over the period 1998 to 2001. In the fall of 2001, a massive hydrology fix was implemented to upgrade the dikes, water control and water conveyance structures, but despite this fix, the population has not recovered to its late 1990s levels. As of 2012, the population has decline from about 14,000 breeding adults in 1998 to about 1,954 breeding adults (M. Hayes, pers. comm.).

The hydrology of the Black River has been altered to the extent that Black Lake no longer flows south into the Black River. Changes to the outflow of Black Lake started in the 1920s when Black Lake Ditch was constructed and continued as changes were made to the ditch in 1952 and 1976. The 1960s construction of a pipeline across the Black River left spoils in the river, and this combined with beaver activity and vegetation growth, completely reversed stream flow by the 1980s (Smith and Wenger 2001). The impact of these changes on Oregon Spotted Frogs is unknown but warrants examination.

The slow recovery of Oregon Spotted Frog breeding numbers at Trout Lake's West Side breeding sites may be related to hydrological changes. In recent years, this area is mostly dry by late summer (Keyna Bugner, pers. comm.). Yet, during the September 2000 to January 2001 Oregon Spotted Frog winter telemetry study, this area held water the entire study period including areas with water over a meter deep (L. Hallock, pers. ob.) even with precipitation that was unusually low (7.86 in. compared to 24.11 in. total average for the period 1971-2000; Appendix B).

Aquatic pollutants. A growing body of evidence indicates that chemical contaminants are contributing to worldwide amphibian declines (Sparling et al. 2001, Blaustein et al. 2003). Amphibians are particularly vulnerable to contaminants because of their highly permeable skin, unshelled eggs and biphasic life cycle (Linder et al. 2010). Of particular concern are herbicides, fungicides, heavy metals, nitrogen and acidification. Marco et al. (1999) found that frogs, including Oregon Spotted Frogs, exposed to high levels of nitrite and nitrate had reduced feeding activity, swam less vigorously, displayed disequilibrium and developed malformations. Exposure could also result in death. Kirk (1988) reported mortality of Columbia Spotted Frogs after DDT spraying in an Oregon forest.

Most chemicals, including many widely used pesticides and herbicides developed after World War II, have not been well tested on amphibians. Evidence is beginning to accumulate that suggests that the detrimental effects of aquatic contamination on amphibians are underestimated using the approaches commonly applied in ecotoxicology investigations (Linders et al. 2010). Research has revealed that some of these contaminants can have insidious impacts on frogs such as feminization of males (Hayes et al. 2006, Rohr and McCoy 2010) and weakening of immune systems (Blaustein et al. 2003), and can produce trophic changes in the food chain (Boone and Semlitsch 2002). The risk of chemical contaminant exposure will intensify with human encroachment on Oregon Spotted Frog habitat.

Another emerging concern for aquatic species is the accumulation of chemicals from human waste, as well as grooming and hygiene products (e.g., shampoo, sunscreen, etc.), in the environment (Linder et al. 2010). These chemical contaminants include hormones, pharmaceuticals, and caffeine. These biochemically active compounds are widespread in low but measurable part-per-trillion levels in surface and groundwater. The concentrations detected are too low for acute toxicity hazard in amphibian species but chronic low level exposure may cause developmental or reproductive effects (Daston et al. 2003). The impact, if any, of these low concentrations of chemicals on amphibians has not been well-studied.

Other chemical pollutants are also having dramatic impacts on the environment. Chloroflurocarbons have depleted stratospheric ozone resulting in long-term increased UV-B radiation at the surface of the earth. The mining and utilization of fossil carbon sources is resulting in acidification of water bodies and climate changes. These environmental changes have lethal, sublethal, direct, and indirect impacts on amphibian populations (Blaustein et al. 2003).

Altered Predator Communities and Non-native Animal Species

Non-native animal species will continue to be a challenge in the conservation of Oregon Spotted Frog populations with effects likely to become worse in the future as more species arrive. Introduction of non-native predators can have both direct and indirect impacts. Novel predators can increase predation pressure on one or more life stages and predatory interactions can effectively create a barrier that prevents access to necessary habitats (Bradford et al. 1993, Pilliod 2001, Pilliod and Peterson 2001). A novel species may compete directly with Oregon Spotted Frogs for food or may alter food webs (Adams et al. 2003, Pearl et al. 2003, Pearl et al. 2005b). While bullfrogs and game fish are of greatest concern, other exotic species may also be a threat (e.g., exotic crayfish). In the future, as development encroaches on Oregon Spotted Frog habitat, the impacts from native predators that thrive in the presence of human habitations (e.g., raccoons, skunks and corvids) may also increase. Attempts to manage these threats may be complicated by conflicts among interest groups (Soulé 1990).

Non-native fish. Fish planting coincided with the westward movement of settlers in the late 1800s. Millions of non-native warmwater game fish, especially members of the sunfish/bass/crappie family (Centrarchidae), perches (Percidae), catfishes (Ictaluridae) and pikes (Esocidae) were shipped from the East by railroad under the direction of the United States Fish Commission. By 1900, warmwater species were common in many of the lowland lakes of the state. Coldwater game fish, including Brook Trout, Lake Trout and Brown Trout, were also introduced (Lampman 1946, WDFW 2005).

Besides direct predation, predatory fish can have complex trophic interactions that affect the biomass, density and species composition of the lower trophic levels. These cascading trophic changes have the potential to alter food availability for all life stages of frogs. These impacts, however, are complex and depend on fish species, fish abundance, predator suite, and habitat features of the introduction site (Adams 1996, Hecnar and M'Closkey 1997a, Tyler et al. 1998, Pilliod and Peterson 2001). Few data are available that directly attest to the effects of fish on Oregon Spotted Frogs. Nonetheless, the effects of non-native fish have been especially dramatic in the western states because introductions were to water bodies nearly or completely devoid of fish. Correlation studies suggest introduced fish are linked with frog declines at high-elevation sites and basins in California and Idaho, including three species closely related to Oregon Spotted Frogs: Southern Mountain Yellow-legged Frog (*R. muscosa*), Cascades Frog, and Columbia Spotted Frog (e.g., Bradford 1991, Fellers and Drost 1993, Knapp and Matthews 2000, Pilliod and Peterson 2001; see also Hayes and Jennings 1986). To investigate further, Vredenburg (2004) experimentally manipulated the presence and absence of widely introduced rainbow trout and brook trout to test the hypothesis that their introduction had contributed to the decline of the Southern Mountain Yellow-legged Frog. His work established that Southern Mountain Yellow-legged Frog tadpoles were vulnerable to trout predation and that removal of introduced trout resulted in rapid recovery of this frog population.

The threat of game fish to Oregon Spotted Frogs is inferred based on the impacts observed on closely related frog species and the fact that Oregon Spotted Frogs occur primarily at locations without game fish. Hayes (1997a) provided data that suggested historical localities where Oregon Spotted Frogs persisted had less non-native game fish than those where spotted frogs were no longer found. Pearl and Adams (2009) found a negative relationship between local Oregon Spotted Frog population size (based on egg masses census) and sites that had potential overwintering habitat that was accessible to non-native game fish. Warmwater game fish are of particular concern because they use the same habitats as Oregon Spotted Frogs and are predators on frogs and larvae (Hayes and Jennings 1986, McAllister and Leonard 1997, Wells 2007).

At the Black River, non-native predatory game fish occur primarily in the Black River proper and are largely absent near the primary habitats occupied by Oregon Spotted Frogs (K. McAllister, M. Hayes, pers. comm.). At Trout Lake, native game fish are Rainbow and Cutthroat trout (Phelps 1990, USDA-Forest Service 1996). Stocking activities were initiated in 1936 and continued until 1993. WDFW stocked Brook and Rainbow trout from1960-1993 with only two gaps (1966-1968, 1974-1975). At Conboy Lake National Wildlife Refuge, Brown Bullheads are extraordinarily abundant in the conveyance channels of the major creeks and canals during the summer and Eastern Brook Trout are closely tied to the coldwater springs (M. Hayes, pers. comm.). Brown Bullheads also inhabit the lakebed where Oregon Spotted Frog eggs and tadpoles develop (T. Hicks, pers. comm.).

If warmwater game fish were to invade Oregon Spotted Frog breeding habitat, attempts at removal could prove harmful to the frogs. Such an event has a relatively high probability of occurring in the Black River drainage given the proximity of warmwater fish to Oregon Spotted Frog habitat. Rotenone, the chemical used to remove fish, is a broad-spectrum insecticide and piscicide. It prevents animals with gills from utilizing oxygen, resulting in asphyxia (Fontenot et al. 1994). USFWS determined rotenone "May Affect and is Likely to Adversely Affect" federally threatened California Red-legged Frogs (*Rana draytonii*) (USFWS 2002a). Rotenone was determined to have direct toxic effects to California Red-legged Frog tadpoles as well as the invertebrate prey base (Jones and Steeger 2008). Likelihood of individual mortality to tadpoles was determined to be 100%.

The threats from coldwater fish, such as exotic Brook Trout, are related to wetland water levels (Hayes 1997b). In low water years and in winter when hypoxic conditions occur under ice, frogs are forced to move into coldwater springs and creeks occupied by salmonids. Bowerman and Flowerree (2000) suggested that coldwater fish may also limit dispersal of Oregon Spotted Frogs between wetlands when the only aquatic corridor is trout-occupied. Exactly such a pattern has been demonstrated for Mountain Yellow-legged Frog (*Rana muscosa*) and Eastern Brook Trout in the southern Sierra of California (Vredenburg 2004, Knapp et al. 2007). In addition, hatchery fish may also carry pathogens that can infect amphibians (e.g., S*aprolegnia* [*S. ferax*]; Daszak et al. 1999, Kiesecker et al. 2001; iridoviruses, Mao et al. 1999) and communal egg layers, like Oregon Spotted Frogs, may be more vulnerable (Blaustein et al. 1994, Kiesecker and Blaustein 1997).

American Bullfrog. Bullfrogs are native to the eastern United States and are the largest frog in North America (normal size up to 150 mm SVL [Stebbins 2003] with records around 203 mm [Conant 1986]). They were introduced widely to western states starting in the early 1900s (Nussbaum et al. 1983; Jennings and Hayes 1985). They are primarily a "shore frog" but will disperse overland on warm rainy nights. Bullfrogs are opportunistic predators that will consume anything that will fit in their mouths (Nussbaum et al. 1983). They are prolific with one female laying 6,000 to 20,000 eggs at one spawning and the larval period is prolonged (usually > 1 year; Nussbaum et al. 1983). In their native range, bullfrogs structure the amphibian community by forcing smaller frogs to use less optimal habitat to avoid predation (Hecnar and M'Closkey 1997b). The consequence of this is lower rates of reproduction for the smaller frog species. Bullfrog tadpoles also have a competitive advantage over most other tadpoles because they are unpalatable to fishes (bass, sunfish, bullheads; Kruse and Francis 1977). Fish convey an additional benefit to bullfrogs by preying on dragonfly naiads that would otherwise prey on bullfrog tadpoles (Werner and McPeak 1994, Adams et al. 2003).

Bullfrogs have been implicated in ranid declines (Lardie 1963, Dumas 1966, Moyle 1973, Licht 1986a, Nussbaum et al. 1983, Leonard et al. 1993, Kiesecker and Blaustein 1998), but the evidence for the hypothesis is equivocal (Jennings and Hayes 1985, Hayes and Jennings 1986, Adams 1999, 2000). The threat to Oregon Spotted Frog populations is primarily inferred (Hayes et al. 2000, Pearl et al. 2004, Pearl et al. 2005b, c). Potential mechanisms of a bullfrog effects includes predation, competition, disease transfer (amphibian chytrid fungus and Tadpole Edema Virus; Daszak et al. 1999, Pearl and Green 2005), and breeding interference (Pearl et al. 2005c). Pearl et al. (2004) compared the vulnerability of Oregon Spotted Frogs and Northern Red-legged Frogs to the effects of bullfrogs. Their results suggested that Oregon Spotted Frogs are more vulnerable because of greater habitat overlap with bullfrogs and less effective escape behavior from bullfrogs.

As of 2011, bullfrogs have been found at seven Oregon Spotted Frog sites including one in Canada (Aldergrove; Haycock 2000), two in Oregon (Sunriver and La Pine; Bowerman and Flowerree 2000) and three in Washington (Conboy Lake [Leonard 1997], Dempsey Creek [K. McAllister and J. Tyson, pers. comm.] and Blooms Ditch [K. McAllister, pers. comm.]). At most of these sites, bullfrogs are relatively rare. At the Dempsey Creek site, bullfrogs had never been found and the closest population was thought to be 4 km away in the Black River (Watson et al. 2003); however in 2010, two bullfrog tadpoles were observed. Only the Conboy Lake site supports a substantial population with long-term overlap (> 50 years; Rombough et al. 2006). Rombough et al. (2006) suggest that this may be a potential driver for the large body size of Oregon Spotted Frogs at Conboy Lake.

Green Frog. Green Frogs are native to the eastern United States (Stebbins 2003). They have been introduced to the western United States and occur at a few lakes in Washington including Toad Lake in Whatcom County (McAllister 1995; WDFW WSDM database). It is unknown whether other populations occur in Whatcom County. They are a medium-sized frog superficially similar in appearance to bullfrogs but smaller (up to about 100 mm SVL; Nussbaum et al. 1983). Unlike bullfrogs, Green Frogs tadpoles are palatable to fish (Werner and McPeek 1994). Overall, Green Frogs are inferior competitors to bullfrogs except in the absence of fish or in ponds that dry frequently (Werner and McPeek 1994, Hecnar and M'Closkey 1997b). Green Frogs co-occur with Oregon Spotted Frogs at Maria and Mountain Sloughs in British Columbia. They are of concern because of their potential to prey on Oregon Spotted Frogs and force them to use suboptimal habitat to avoid predation.

Emerging Diseases

The amphibian chytrid fungus has been implicated as a major contributor to catastrophic global declines of frog populations (Berger et al. 1998, Daszak et al. 1999, 2003). Chytrid fungus causes a skin disease called chytridiomycosis that can be highly virulent in amphibians. The infection can result in physiological changes that inhibit electrolyte transport across the epidermis and cause cardiac arrest and death (Voyles et al. 2009). Voyles et al. (2009, 2012) speculated that disruption of cutaneous function may be the mechanism by which the chytrid fungus produces morbidity and mortality across a wide range of amphibian taxa.

A preliminary assessment by Pearl et al. (2007, 2009b; see also Adams et al. 2010) found that chytrid fungus was widespread geographically and taxonomically in the Pacific Northwest with ≥ 1 detection at 43% (16/37) of sites studied. Of the Oregon Spotted Frogs tested, 57.1% (12 of 21) tested positive, including frogs from Black River and Trout Lake. They found frogs such as Oregon Spotted Frogs, with highly aquatic habitats and life histories, may experience elevated exposure to infection but concluded that it was difficult to assess risk for any of the species because evidence indicated populations had persisted with the disease for a long time.

The direct impact of this disease on extant Oregon Spotted Frogs, if any, appears to be limited. Hayes et al. (2009) suggested that declines at Trout Lake and Conboy Lake in 2006 may have been caused by chytrid infection. However, Conboy Lake study frogs infected experimentally with *B. dendrobatidis* (*Bd*) did not die, and none showed any manifestation of disease (Padgett-Flohr and Hayes 2011). Padgett-Flohr and Hayes (2011) postulated that outcome might be different if the pathogen was novel to the frogs. To date, all Oregon Spotted Frog populations tested have the pathogen (Pearl et al. 2007, 2009a; P. Govindarajulu, pers. comm.).Yet many of these populations have not exhibited declines. A historic epizootic may have affected these populations, and existing populations may represent resistant individuals.

Other pathogens are also of concern but their overall impact on Oregon Spotted Frogs is unknown. The amphibian limb malformation-inducing trematode *Ribeiroia ondatrae* (Johnson et al. 2002) was documented as the cause of an episode of malformed Oregon Spotted Frog metamorphs at Sunriver, Oregon (Bowerman and Johnson 2003). Oomycetes (water molds of the family Saprolegniaceae) have been documented on eggs of Oregon Spotted Frogs from three sites in Oregon (Petrisko et al. 2008). Other pathogens, such as iridoviruses (specifically *Ranavirus*), are potential concerns but have not yet been directly found in Oregon Spotted Frogs. Hatchery-raised fish (e.g., fish pathogen *Saprolegnia ferax*: Blaustein et al. 1994) and amphibian commerce (Tiger Salamanders used as bait; Picco and Collins 2007) including scientific and medical research specimens [e.g African clawed frogs; *Xenopus* spp.] have been identified as sources of amphibian pathogen introductions to the western United States. Native amphibian populations may be more susceptible to disease when under stress and this may increase the incidence of outbreaks of disease (Blaustein et al. 1994, Blaustein and Kiesecker 2002). Consequently climate changes, increased UV-B and environmental contaminants may predispose amphibian populations and may exacerbate disease issues in the future (Daszak et al. 1999).

Geological Catastrophe: Mt. Adams

Trout Lake was formed by a volcanic lahar (mudflow or debris flow) originating at Mount Adams that inundated about 15 km^2 (5.85 mi^2) of the lowland and dammed Trout Lake Creek about 6,000 years ago. About 200 years ago, another lahar originating at Mount Adams filled valleys to depths as much as 50 m (164 ft.), and produced run-ups of as much as 30 m (98 ft.) on objects in its path, but left only thin veneers on valley sides and floors. Three smaller lahars and the debris avalanche of 1921 extend between 5 and 15 km (3–9.32 mi.) from Mount Adams (Vallance 1999). Such geological catastrophes, while relatively rare, are potential threats. Oregon Spotted Frogs are at risk because the remnant populations occupy such small and isolated geographic areas and two of the remaining populations are on the southern edge of the same potentially active volcano.

Climate change

The Intergovernmental Panel on Climate Change reached consensus that human-influenced climate change is occurring. While estimates of global warming during the next century vary, estimates generally are in the range of 2°C to 4°C (3.6–7.2°F) and as high as 7°C (12.6°F) in the United States (Wake and Vredenburg 2008, based on information in Parry et al. 2007).

Models for Washington, in general, have projected small changes in annual precipitation (+1 to +2%) and some models project changes in the seasonal precipitation cycle resulting in wetter autumns and winters and drier summers. All models indicate warmer winter temperatures resulting in less winter snowpack. This will result in increased winter stream flow, reduced spring snowpack, earlier spring peak stream flow and decreased summer stream flow (Climate Impacts Group 2009).

Oregon Spotted Frogs inhabit two different ecoregions in Washington and the impacts of climate changes will differ in each ecoregion. For instance, the Puget Trough region has warmed at a rate substantially greater than the global trend. Much of this warming took place in the second half of the 20th century and the Pacific Decadal Oscillation accounts for some of this trend. The projected changes in Puget Sound include additional increases in temperatures and increases in water temperature of rivers and streams

(Snover et al. 2005). In the East Cascades Ecoregion, the Klickitat subbasin, including Trout Lake and Conboy Lake, is at high risk of losing much of its seasonal snowpack (Graves 2008). Aside from the relatively small area around Mt. Adams where winter temperatures are very cold, the remainder of snowfall mostly occurs where winter temperatures are from -5° to -2° C (23° to 28.4° F). These areas have the highest chance of having a snow-dominated regime converted to rain-dominated regime. This will increase fall and winter inputs, decrease summer inputs, and will shift the timing of spring water input to earlier in the year (Graves 2008).

Increased climate variability will increase the vulnerability of high-risk species such as Oregon Spotted Frogs (Wake and Vredenburg 2008). The changes in precipitation patterns, especially the shifting of spring water input to earlier in the year and the decrease in summer inputs, are likely to negatively affect Oregon Spotted Frog populations. Increased variability in early-season hydrology can place eggs deposited in shallow water at greater risk of desiccation, which is already naturally an important source of mortality for the egg stage. Survival of the tadpoles depends on persistence of water in the seasonal wetlands until the tadpoles can move to more permanent waters. At the Dempsey Creek site, a difference of 8 cm (3.5 in.) lower precipitation significantly reduced larval recruitment (Watson et al. 2003). The shrinking of wetland extent during an extended summer drought could also reduce habitat for this aquatic species, make their wetlands vulnerable to expanding shrub-scrub habitat and invasive species such as reed canarygrass and concentrate the frogs in small areas where they are more vulnerable to predators.

Other impacts from climate change are difficult to predict due to unknown factors such as future increases in human population growth, rate of increased resource demand, changes in invasive flora and fauna, and development near sensitive habitats (Climate Impacts Group 2009).

RECOVERY

RECOVERY GOAL

The goal of the recovery plan is to establish and maintain self-sustaining Oregon Spotted Frog populations in Washington.

The Oregon Spotted Frog Recovery Plan provides strategies to increase population abundance in each occupied area, to find additional extant populations and, establish new populations across the geographic range. Habitat management will be necessary to produce these results and is an essential part of the recovery plan for this species.

Oregon Spotted Frogs require a mosaic of wetland habitat types including short vegetation with full sun exposure. This habitat type is typical of early successional stages that result from some type of disturbance (e.g. fire, beaver dams, flood events). In drainages where these natural processes no longer occur or are too limited to provide suitable habitat, other disturbance mechanisms must be found to maintain or create this habitat. Currently, short vegetation is maintained at occupied sites by a mix of natural processes (primarily beaver activity) and land use/management activities that include cattle grazing, mowing and haying. Research will be necessary to determine how to best manage/control for reed canarygrass especially in western Washington where this species is not compressed by snowpack. The use of shade cloth to kill reed canarygrass, followed by re-vegetation with native rushes, sedges and grasses, is being investigated at the Trout Lake Oregon spotted frog site as an option.

Currently, grazing by cattle is essential at many sites to control reed canarygrass in the seasonally flooded pastures used by Oregon Spotted Frogs for breeding. Future use of grazing in these riparian areas, however, may not be possible due to water quality issues. This is already the case in the Samish River drainage where cattle are being excluded from riparian areas along the river to improve water quality for salmon and to protect shellfish beds at the mouth of the river. Alternative methods to control reed canarygrass in these areas will need to be found to address this recent change in tools available for habitat management.

Water management is another habitat factor that must also be addressed. Hydrology at most of the spotted frog sites has been altered due to the presence of canals and drainage ditches that were constructed to facilitate more rapid drying for hay production and pasture. Trout Lake Natural Area Preserve is the first site to address management of these canals. Work to date has included placement of a water control structure on a major canal that has enabled retention of water for longer time periods in the eastern areas of the wetland. Select canals have also been filled or blocked to prevent the canals from draining portions of the wetland. Addressing water management at Conboy NWR will be a critical need for recovery of the species.

When the species is downlisted in Washington, permanent mechanisms must be in place to maintain critical habitat qualities - ideally without costly management practices. If on-going management activities are required, these must be documented in a site management plan that includes habitat management and funding strategies.

The following section of the Oregon Spotted Frog Recovery Plan outlines the steps needed to achieve these goals and to downlist the species.

Recovery Zones

Oregon Spotted Frog recovery activities will take place in two recovery zones (Fig. 26). The recovery zones cover a larger area than the conservative depiction of the Oregon Spotted Frog's historic range (Fig. 11) to allow consideration of additional reintroduction sites. The entire Puget Trough Ecoregion was selected based on elevation, climate and vegetation similarities assumed suitable for Oregon Spotted Frogs. The pattern of documented occurrences also suggests the species was more widely distributed than the historical reports indicate. The eastern recovery zone includes the portion of the East Cascades Ecoregion bounded by the White Salmon River and Klickitat River watersheds. The two ecoregions have distinctly different climates, habitats, and human-related pressures.

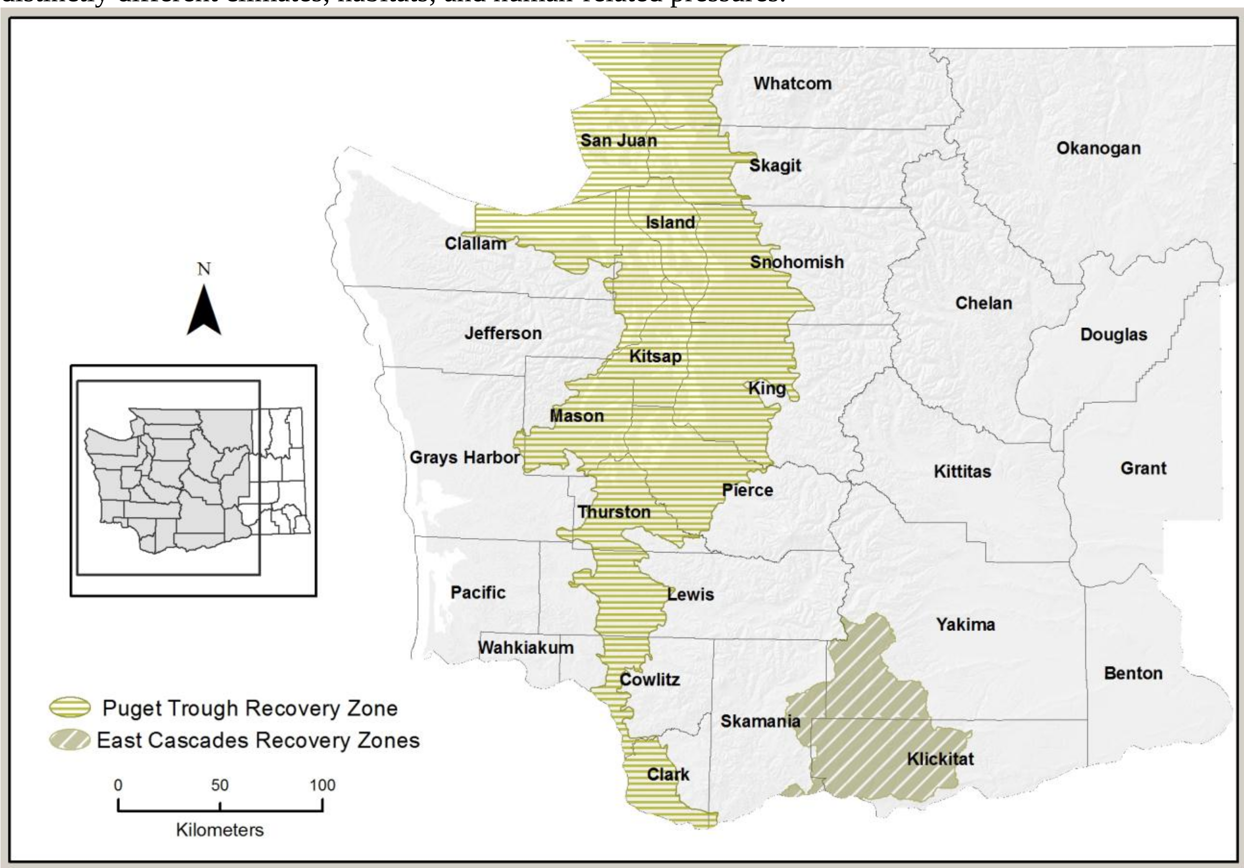

Figure 26. Oregon Spotted Frog recovery zones for Washington.

RECOVERY OBJECTIVES

The Oregon Spotted Frog will be considered for downlisting to Threatened when the following conditions are achieved:

1. **Washington has populations in at least six drainages that produce a total of ≥7,500 egg masses annually and each drainage supports a minimum of 500 egg masses from frogs close enough in distribution to exchange genes. These population levels must be met in 7 of 10 years sampled. A declining trend in the last three years would result in an extension of the sampling period for three additional years to verify that the populations are stable or increasing.**

2. **At the time of downlisting, at least one recovery zone supports a minimum viable population.**

3. **Management plans and funding are in place to maintain suitable habitat at each occupied site within the six drainages over the long-term.**

The Oregon Spotted Frog will be considered for downlisting to Sensitive when the following conditions are achieved:

1. **Washington has populations in at least six drainages that produce at total of ≥10,000 egg masses annually and each drainage supports a minimum of 500 egg masses from frogs close enough in distribution to exchange genes. These population levels must be met in 7 of 10 years sampled. A declining trend in the last three years would result in an extension of the sampling period for three additional years to verify that the populations are stable or increasing.**

2. **At the time of downlisting, both recovery zones support a minimum viable population.**

3. **Management plans and funding are in place to maintain suitable habitat at each occupied site within the six drainages over the long-term.**

After the species is downlisted to Sensitive, a management plan will be prepared that includes the recovery objectives to delist the species.

Rationale

Viable Oregon Spotted Frog populations in Washington must be large enough to withstand localized fluctuations in recruitment due to environmental variability and must be able to maintain genetic heterogeneity over time. Distribution of local populations must allow for genetic exchange at a high enough frequency to prevent inbreeding while being dispersed across the landscape enough to preserve the species, and its genetic variation, in case one or more populations is lost to disease or extreme environmental events. The ideal recovery would be to have genetically healthy and robust populations across the entire historic range in Washington. This is no longer possible, and the recovery objectives reflect this reality. Instead, the objectives are to maintain the extant populations at sizes and distributions that will guarantee their persistence over time. If this is not possible due to land use conflicts or other issues, then new populations may need to be found or established in other watersheds.

Populations must be maintained above a certain size to avoid inbreeding depression, accumulation of deleterious mutations and to retain evolutionary potential. The minimum viable population (MVP) is the estimated number of individuals required for a high probability of survival over time. The MVP can be estimated using a number of techniques including a population viability analysis (PVA) using demographic or genetic data; however, an accurate PVA requires an intensive genetic study or information on population variables not necessarily well understood for the Oregon Spotted Frog. Franklin (1980) proposed the 50/500 rule whereby an effective population size (N_e) of 50 is required to prevent unacceptable rates of inbreeding and an N_e of 500 is required to ensure overall genetic variability. N_e has not been calculated for Oregon Spotted Frog populations in Washington and there is criticism of Franklin's premise. Consequently, the following is provided only as a general estimation until more accurate information is available specific to Washington populations.

Phillipsen et al. (2009) compared the adult Oregon Spotted Frog census population (N = 428) from a breeding site near Sunriver, Oregon to the effective population size (N_e = 36.7) with the result of N_e/N = 0.086, which fell within the general range of DNA-based estimates for ranids. The 50/500 rule provides that an Oregon Spotted Frog population of >581 breeding adults (N/N_e = 50/.086) would be required to prevent inbreeding depression and a population of 5,814 breeding adults (N/N_e = 500/.086) would be required for a high probability of survival over time (= MVP). In Washington, populations are monitored by egg masses rather than by the number of breeding adults. As such, an isolated population similar to the one studied by Phillipsen et al. (2009) would need to produce ≥290 egg masses annually to prevent inbreeding depression and would need to produce ≥2,900 egg masses annually to ensure a high probability of survival over time.

Reed et al. (2003) used population viability analysis to estimate MVP size for 102 species that would have a 99% probability of persistence for 40 generations. The mean and median estimates of MVP were 7,316 and 5,816 adults respectively. As a result of their simulations, they suggest that conservation programs for wild populations need to be designed to conserve habitat capable of supporting approximately 7,000 adult vertebrates to ensure long-term persistence. Traill et al. (2010) concluded that biologically relevant MVPs would be at least 5000 adult individuals, or 500 simply to prevent inbreeding, and this would be needed while also addressing the associated mechanisms of decline. Flather et al. (2011) criticized these studies and concluded there was no single "magic" population size that guarantees population persistence. While they did not support a universally applicable MVP threshold, they conceded that they suspected ensuring long-term persistence would require multiple populations totaling thousands of individuals. The MVPs that will be developed specific for each Washington Recovery Zone will likely be for a population that has 5,000–7,000 adults that produce around 2,500–3,500 egg masses annually.

Using the Phillipsen et al. (2009) and Franklin (1980) example above, only two Oregon Spotted Frog populations have approached an MVP of 2,900 egg masses produced annually. Conboy Lake population exceeded this number in 1998-2000, 2004-2005 and Oregon's Big Marsh site had about 2,611 egg masses in 2007. Oregon's Sunriver Site had 1,132–1,182 egg masses in 2001, 2006, 2009 (USFWS 2011). Population size is related to habitat size (Pearl and Hayes 2004) and these are the largest occupied areas that remain. When comparing occupied areas in Washington, the population at Conboy Lake occupies about 3,000 ha (7,410 ac.) whereas the Trout Lake population occupies about 469 ha (1,160 ac.) and the six Black River subpopulations combined occupy about 400 ha (988 ac.). Based on this, it is unlikely that Trout Lake and Black River will support populations that produce 2,900 egg masses under current conditions and land use. It is also improbable that such a large Oregon Spotted Frog population would have gone undetected. Therefore, under current conditions, the only Washington site capable of supporting an MVP that produces ≥2,900 egg masses annually is Conboy Lake. To support a MVP of similar size in the Puget Trough Recovery Zone will require expansion of occupied habitat for the target population.

In July 1997, when Oregon Spotted Frogs were first listed as Endangered in Washington, the only known sites were Trout Lake, Conboy Lake, and the Black River subpopulation at upper Dempsey Creek. The first full population census was spring 1998. At that time 7,993 total egg masses were found at all three locations. Eighty-six percent (7,018) of the egg masses were produced by the spotted frog population at Conboy Lake. As of 2012, the known area of occupation within the Dempsey Creek drainage has expanded and five additional Black River tributaries are known to be occupied. At Trout Lake, six additional breeding areas have been found within the Lower Trout Lake Creek drainage. In Whatcom and Skagit counties, three new occupied drainages were discovered in 2011-2012. Statewide in 2012, however, only 3,684 egg masses were documented at all these sites. This is a decline in egg mass production of about 46% since the species was listed as State Endangered and clearly indicates that all the newly discovered populations have not made up for the loss of approximately 86% of egg mass production at Conboy Lake. Absent discovery of other large populations in Washington, the recovery of the Conboy Lake population is of central importance to the status of the species in the state.

Egg masses have been intensively monitored at Conboy Lake, Trout Lake, and Black River population complexes for 15-17 years respectively. Annual egg mass production has fluctuated at most breeding aggregations and in some cases, rapid declines were observed. Because of this, the recovery objectives require that all populations maintain the set population goals for at least seven of ten consecutive years and the number of egg masses must be stable or increasing in the last three years. This will indicate that adaptive management has progressed to the point where populations can be sustained at sizes that do not cause concern for the fate of the population. Based on past observation, egg mass production for each population will need to exceed the recovery objectives in some years to meet the recovery goals over the monitoring period.

The Oregon Spotted Frog population at Conboy Lake was once the largest in the entire range and produced 7,018 egg masses in 1998. It is not known if such high egg mass production can be maintained over time. It is recommended, however, that this population be recovered to 60–80% of the egg mass production observed in 1998 which would be approximately 4,210– 5,614 egg masses. Recovering the Conboy Lake population complex will require rehabilitating the system to provide the most suitable Oregon Spotted Frog habitat. Water issues at the site are complex due to a water control infrastructure and off-site issues that influence how much water enters the Refuge and how long water is retained. For successful Oregon Spotted Frog recruitment, the Refuge must be able to maintain stable water levels during the period of embryonic development and hold water long enough for the larvae to complete development to metamorphosis. This will require communication between the biologists monitoring the spotted frogs and the managers who regulate water and habitat conditions. Natural wetland succession and overgrowth of reed canarygrass will also need to be managed either with short-term fixes such as mowing and haying or longer-term solutions such as restoration to early successional native vegetation. In addition, research will be needed to determine dispersal corridors and other significant habitat features for Oregon Spotted Frogs, as well as the impact of non-native predatory fish (e.g., Brown Bullhead) and bullfrogs.

At this time, all major breeding locations are thought to have been found in the Lower Trout Lake Creek drainage (Hallock 2012). The Trout Lake population complex has produced over 900 egg masses 5 times in 16 years of monitoring and likely has the potential to produce > 1,000 egg masses with suitable habitat and precipitation conditions. Increasing egg mass production > 1,250 may require habitat expansion beyond the current known occupied area. If elevation is not a limiting factor, then it might be possible to facilitate colonization with translocation into the upper watershed if suitable wetland and riparian conditions are present. If the population is limited by elevation, then expansion would require conversion of agricultural lands to wetland. Whether or not this is feasible is unknown at this time. Another unknown is the consequence of the Trout Lake population being less genetically diverse than the Black River and Conboy Lake populations due to a past population bottleneck or founder effect or both (Blouin 2000).

The Trout Lake population declines of 2001-2007 were rapid and the cause not well understood but water level issues are suspected. As discussed previously, precipitation levels were below normal from fall 2000–2006, including two years of severe drought. Egg mass production started to decline spring 2001. The trend of declining egg mass production started to reverse in 2008. As of 2012, the eastern breeding sites were producing egg masses at levels observed in the late 1990s but breeding at the western sites remained below egg mass numbers observed in those years. A return to more moderate precipitation patterns and the installation of a water control structure in 2005 may provide the reason for the difference in recovery rates between the East Marsh and West Side breeding aggregations. The water control structure allowed more water to be held in eastern areas of the wetland for a longer period of time and this may have facilitated the recovery of the eastern breeding aggregations. Issues dealing with habitat conditions and changing hydrology at the western breeding areas started to be addressed in 2012 by the Washington Natural Areas Program. Controlling the negative impacts of reed canarygrass will be an on-going management need. Issues of vegetation succession may also need to be addressed to maintain oviposition habitat in some areas of the preserve.

The Black River population complex includes subpopulations that are within the same genetic neighborhood (≤10 km; Blouin et al. 2010) but are isolated from each other by creek distances not typically moved by Oregon Spotted Frogs. Genetics data are needed to understand the genetic relationship between the subpopulations within the complex. Barriers to dispersal, such as the presence of warmwater fish, may be present in the Black River. The Black River Flood Plain population has produced over >550 egg masses and the Dempsey Creek population has shown the potential to produce about 300 egg masses. These populations need to be maintained at these sizes to prevent inbreeding depression. This will require management to address natural habitat succession and reed canarygrass invasion. Research will be needed to determine how to optimize livestock grazing for vegetation management while preventing riparian and water quality degradation, as well as developing techniques for preventing succession and removing or controlling reed canarygrass.

The rest of the Black River subpopulations are at risk due to small size. Persistence and stability of these small populations through time will require increasing the population size in each tributary concurrent with expansion of the occupied areas. Supplementation with frogs from the more robust subpopulations may be necessary to increase population size and genetic health but this is not the preferred action. If population numbers cannot be increased, it may be necessary to establish population(s) in new areas of the drainage with greater habitat potential. Recovery efforts will be enhanced if connectivity can be established between subpopulations. The extirpated Blooms Ditch site may be close enough to the Black River Floodplain population to be naturally re-colonized by Oregon Spotted Frogs if the Blooms Ditch habitat is set back to an early successional condition and reed canarygrass growth is controlled.

More survey work will be needed to determine the extent of occupation and abundance of Oregon Spotted Frogs in the Sumas River, Black Slough and Samish River drainages. If the Sumas River and Black Slough occurrences are small and localized, then human intervention may be needed to guarantee their persistence. The shrubs that were planted at Black Slough in Oregon Spotted Frog breeding habitat should be removed before the shrubs grow tall enough to shade this habitat.

Increasing viability of the six known population complexes may not be enough to guarantee long-term (> 100 years) persistence of the species. Additional populations may need to be found or new populations established. These populations must be large enough to maintain genetic heterogeneity, survive periods with low recruitment and persist through environmental perturbations. Because of the short life span of these frogs, a climatic fluctuation that results in five years of unfavorable precipitation could cause localized declines and even extirpation of some breeding aggregations. Maintaining robust population complexes (≥1000 adults) dispersed over a watershed with many scattered breeding locations, including some that are large (>250 egg masses produced annually), will aid in ameliorating the impact of unfavorable weather cycles. Aquatic connections that allow movement between breeding areas and to a variety of habitats will allow the frogs to maintain genetic health and allow them to shift to new areas as suitable habitats become available. Current knowledge suggests that Oregon Spotted Frogs are relatively limited in their movements and no individual has been documented to move over 3 km. Consequently, breeding aggregations within a watershed must be connected by aquatic corridors and be within distances that allow the frogs to exchange genes.

Once Oregon Spotted Frogs are down-listed to Sensitive, a management plan will be prepared with management objectives and population targets required for de-listing the species in Washington.

Recovery Strategies and Tasks

Conservation and management of the Oregon Spotted Frog population in Washington is a cooperative effort of many entities in state, federal and private sectors. Recovery strategies and specific tasks are detailed in this section. Priority responsibility, as well as potential partners, for implementation of each task is detailed in Table 5.

1. Monitor Oregon Spotted Frog populations.

1.1 Conduct annual egg mass census.

Census egg masses annually at all breeding areas to determine population status and trends. For breeding areas that cannot be monitored annually (such as sites that are too large, have too much snow, or have restricted access), select a subset of the most significant sites for long-term monitoring with site-wide monitoring every five years. Determine if a model can be developed to predict the number of egg masses at each site with less survey effort.

1.2 Monitor larval development and dispersal.

Little is known about the success of larval movement from their origin in seasonally flooded waters to permanent waters. It is possible, as observed by Watson et al. (2000), that some breeding aggregations lay eggs at oviposition locations that are population sinks. In these cases, tadpoles become trapped and die in pools that dry or become hypoxic before the tadpoles metamorphose. Identification of these locations would help determine where habitat management is needed.

1.3 Document monitoring methods and develop a standardized monitoring protocol.

Develop a standardized monitoring protocol that allows for egg mass comparison between occupied sites. This should include guidelines for reporting and archiving information, as well as what information is essential for inclusion in the WDFW WSDM corporate database. The protocol should also describe current egg mass monitoring methods used at each site including monitoring history and any issues that complicate monitoring at the site.

2. Conduct surveys for new Oregon Spotted Frog populations.

2.1 Augment knowledge about historical distribution.

Augment data on the historical distribution of Oregon Spotted Frogs in McAllister (1995) and McAllister and Leonard (1997) by examining museum collections that were not available in the 1990s. In addition, photographic databases of local historical societies will be examined for additional records. Upon completion, update the WSDM corporate database as needed.

2.2 Create a model of potentially occupied habitats based on historical sites.

Build on the model created by WDFW in 2004 (Germaine and Cosentino 2004) using any new historical data and new statistical approaches that would allow a specifiable level of confidence to better estimate historical and potential Oregon Spotted Frog habitat.

2.3 Develop inventory methodology to determine occupancy and absence.

In 2005, WDFW developed a draft protocol for species detection. The document provided information on optimal survey conditions and habitat. In 2010, WDFW developed a protocol specifically for egg mass detection. Neither document addressed determination of absence or issues related to probability of detection. Pearl et al. (2009b) produced an inventory protocol that focused on detection of metamorphosed forms.

2.4 Develop an isoline map of Oregon Spotted Frog breeding phenology.

In Washington, Oregon Spotted Frog inventory efforts focus on detection of egg masses. The entire breeding event is limited to 4-5 weeks per year. Understanding differences in breeding phenology throughout the Washington range is essential for properly timed egg mass surveys. Hopkin's Bioclimatic Law can be used to predict differences in spring phenology between locations at different elevations, latitudes and longitudes where arrival of spring is delayed northward, eastward, and upward (Hopkins 1920). These predictions can be used to develop an isoline map of Oregon Spotted Frog breeding phenology. Knowledge about local site conditions and data from local weather stations can be used to refine the isolines.

Oregon Spotted Frog breeding activity naturally shifts over a three week period each year depending on annual weather conditions. Consequently, the map needs to include reference sites from which other breeding activity is calculated annually. Based on current knowledge, Dempsey Creek (Black River population, Thurston County) is the reference site for Puget Sound Ecoregion. Web postings and social media can be used to disseminate this information. In the East Cascades, Oregon Spotted Frogs at Conboy Lake start breeding before those at Trout Lake, and therefore, Conboy Lake is the reference site for that region.

2.5 Expand inventory efforts.

New sub-populations may be found within occupied drainages. Species experts should document areas that have been well surveyed without detections (negative data) and also recommend areas to be surveyed. Also, surveys will need to be expanded beyond the historically occupied drainages. New populations discovered in Whatcom and Skagit counties in 2011-2012 were on private lands in drainages where Oregon Spotted Frogs had not been previously documented. It is possible that other undiscovered populations may also persist elsewhere. Establishing relationships with private landowners will be essential towards these efforts.

Watson et al. (2000) recommended that a systematic attempt to identify suitable habitat should seek to identify the following features:

- At least 20 acres of contiguous and shallow emergent palustrine wetland habitat.
- Low gradient stream course or ditch draining the wetlands.
- High seasonal hydrologic fluctuations with extensive water in winter/spring and limited in late summer.

Watson et al. (2000) made these recommendations for the Chehalis River basin but these same features would be the focus in any drainage.

3. Conserve and Enhance populations.

3.1 Facilitate survival.

3.1.1 Facilitate survival of embryos.

Stranding and freezing are the two main causes of embryo mortality in Washington. Currently, these mortalities are allowed to occur without interference. Justification for this is based on the fact that stranding and freezing are natural occurrences; altering the outcome of these events may have undesirable selection consequences. Because of intrinsically high rates of mortality (Licht 1974), loss of a large percentage of egg masses in any one year may not impact population demographics except in extreme cases. Furthermore, water levels fluctuate naturally during the embryo development period. This often results in egg masses being exposed for a few days and then being re-inundated by a rain event. Therefore, deciding when to intervene is complicated. Further complicating this situation is the fact that water levels fluctuate more rapidly in areas with semi-permeable and impervious surfaces. Because of this, the threat to embryos is expected to increase as human development and land use encroach on Oregon Spotted Frog occupied wetlands.

Changes to precipitation patterns predicted to occur with climate change could also exacerbate spring water fluctuations. Efforts to recover the species require increasing the population size at extant sites and reintroducing the species to unoccupied site. Rather than allowing embryos to perish, it may be prudent to protect the eggs or salvage them for translocation or reintroduction activities. It is therefore recommended that the Oregon Spotted Frog Working Group convene to produce guidelines for protection and salvage of stranded egg masses.

3.1.2. Facilitate survival of larvae.

Maintaining aquatic connectivity for tadpole dispersal from seasonally inundated breeding areas to permanent water is important for facilitating tadpole survival. Significant mortality can result when tadpoles become isolated in breeding pools away from more permanent waters (Licht 1974, Watson et al. 2003). Besides being vulnerable to desiccation, tadpoles may succumb to low dissolved oxygen levels in isolated pools and ponds during summer (Watson et al. 2000). To maintain connectivity, reed canarygrass must be managed to prevent overgrowth and thatch development in dispersal corridors. Livestock grazing must be maintained unless an alternative vegetation control method has been established. Otherwise, reed canarygrass will grow unchecked and native wetland species that were suppressed by grazing (e.g., bur-reed *Sparganium* sp.) will be released. Native emergent macrophytes, such as bur-reed, trap sediments and can reduce or cut off aquatic corridors over time.

At Conboy Lake, water retention is managed by the refuge and complicated by many factors. The refuge manager needs information on the progress of tadpole development to understand how to best balance the water needs of Oregon Spotted Frogs with both refuge management and the needs of surrounding farmers.

3.1.3 Facilitate survival of juvenile and adult frogs.

Maintaining aquatic corridors and suitable habitat, especially during summer (dry season) and winter, are necessary for survival of metamorphosed frogs. Site-specific research is needed to better understand how to manage habitat. Additionally, little is known regarding habitat partitioning between juvenile and adult Oregon Spotted Frogs, or between adult males and females. Examining habitat partitioning has been hampered by the difficulty of marking and tracking small frogs. Most adult males are too small to carry a radio-transmitter, as are juveniles, and juveniles are too small to receive PIT tags. Recaptures of PIT tagged frogs has also proved challenging except during the breeding season when the frogs aggregate at known locations. Because of this, most information available on non-breeding habitat is based on studies of adult females.

3.1.4 Determine when to intervene to save a breeding cluster, subpopulation or population.

In the Black River, the Blooms Ditch subpopulation was extirpated and the Pipeline breeding aggregation declined to the point where only 19 egg masses were found in 2012. At Trout Lake, the USFS Beaver Pond breeding aggregation declined to produce only 16 egg masses in 2011. In 2012, no egg masses were found. At Conboy Lake, some units of the Refuge no longer support spotted frog breeding and others now support only small breeding aggregations. It is possible that some former breeding locations may be isolated enough by distance that they will not be rapidly recolonized without human intervention. The situation in the Sumas River or Black Slough drainages could be even more critical if those populations are indeed small and isolated because declines could potentially result in loss of Oregon Spotted Frogs from an entire drainage.

It is therefore recommended that guidelines be developed to determine when to intervene to save a declining breeding aggregation, subpopulation or population. The guidelines should include methods to use for intervention (e.g., captive rearing or translocation). It is important to understand the genetic relationship (gene flow) between breeding aggregations or subpopulations in each population complex to inform such decisions. For this reason, it is recommended that a conservation geneticist be consulted and appropriate genetic analysis be done for each population complex.

3.2 Prevent introductions of non-native predatory species.

Bullfrogs and exotic fishes are potential threats to Oregon Spotted Frog populations. Eradication of bullfrogs is not possible in open systems due to the bullfrog's remarkable ability to disperse and re-colonize sites. Eradication of fish with rotenone would be deadly to Oregon Spotted Frog tadpoles. Vigilance by site managers to prevent establishment of non-native predatory species is required because no satisfactory remedy exists after the fact.

4. Establish new populations.

4.1 Establish new Oregon Spotted Frog populations.

Based on current knowledge, meeting the goals of the recovery plan may require establishment of new populations. Colonization of new watersheds by Oregon Spotted Frog will probably not happen without human intervention. A translocation/reintroduction plan will be needed to guide efforts to locate suitable introduction sites and provide criteria for evaluation of successful introduction.

4.1.1 <u>Develop a plan to guide reintroduction activities</u>.

Complete a reintroduction plan for the Oregon Spotted Frog. Include guidance for project justification, evaluation of donor site suitability, evaluation and selection of receiving site, maintaining genetic integrity, egg collection protocol, captive rearing methodology, testing for chytrid infection pre-release, post-release monitoring and criteria for evaluation of successful establishment. The plan should be flexible and include benchmarks to guide adaptive management so that adjustments to the plan can be made as new information is available.

4.1.2 <u>Identify wetlands suitable for Oregon Spotted Frog reintroductions</u>.

4.1.2.1 Identify potential translocation and reintroduction sites within the recovery zones using guidelines provided in the reintroduction plan.

4.1.2.2 Rank potential sites based on suitability, ownership, size, and security from exotic predators.

Among sites of similar value, site selection should favor sites maintained by natural processes (e.g., beaver engineering) and that provide habitat for other rare wildlife species and plant communities such as Western Toads, Olympic Mudminnows and Sandhill Cranes.

4.1.3 Conduct genetic analysis to determine genetic health of any remnant populations and to determine the appropriate populations to use for translocation/reintroduction and supplementation activities.

Identify the most appropriate source population for each reintroduction project. Conduct appropriate genetic analyses. Evaluate whether remnant and peripherally important populations will be impacted by artificial gene flow and subsequent loss of genetic distinctiveness that could damage the evolutionary legacy of the species (Hoffman and Blouin 2004). Appraise other genetic costs that can arise from supplementation such as competition between the original and introduced frogs, decreasing effective population size and reducing the genetic variation of the recipient populations, as well as outbreeding depression (Hoffman and Blouin 2004)

4.1.4 Investigate egg mass translocation as a method for reintroduction efforts.

This method requires a healthy donor population that will not be put at risk due to removal of egg masses. The advantages of this method include transferring large numbers of individuals each year (each egg mass has > 500 eggs), all life stages develop in a natural setting and the cost is minimal. It is also possible that transferring egg masses reduces the risk of disease transfer as compared to captive rearing. The main disadvantages of this method are the risks to the donor population from egg removal and the vulnerability of the hatchling larvae to predation at the new site, especially if the number of egg masses transferred is small. If only a small number of egg masses are transferred, then the resulting genetic diversity of the new population will be small (i.e., small number of founders) unless releases can be made for several years.

4.1.5 Use captive rearing of egg masses when appropriate.

Captive rearing of egg masses may be needed for recovery including reintroductions, genetic rescue and to potentially augment existing populations. WDFW will work with zoo and prison rearing facility partners to accomplish rearing goals as needed.

4.2 Monitor frogs at translocation and reintroduction sites.

Continue monitoring Oregon Spotted Frogs at Dailman Lake on Joint Base Lewis-McChord, and at other translocation and reintroduction sites, for a period of at least five years after last translocation.

4.3 Evaluate success of translocation and reintroduction projects.

Each attempt to establish a new population will be evaluated after five years. The overall goal of each project will be to introduce enough frogs to establish a population that will grow without supplementation. The Washington Oregon Spotted Frog Working Group will provide criteria to evaluate success as well as guidelines for when to stop supplementation and how long to continue monitoring activities. This information will be included in the reintroduction plan (see 4.1.1).

5. Protect and manage essential habitat.

5.1 Maintain early succession vegetation structure at breeding areas.

It is critical to maintain breeding habitat with short vegetation in seasonally flooded wetland margins with full sun exposure. Natural processes such as fire, creek-scouring, creek-meandering, and beaver engineering create these conditions. Short vegetation is also maintained by mowing, haying, and cattle grazing. However, caution should be exercised in implementing cattle grazing due to the resulting degradation to water quality and riparian habitat. An adaptive resource management approach is recommended that includes system monitoring to accrue information to improve future management.

5.2 Maintain connectivity between breeding areas and permanent water.

To survive to metamorphosis, the larvae must be able to follow water as it recedes from the seasonally flooded areas of wetlands into more permanent water. To survive during winter, the frogs must be able to move to permanent waters that do not freeze to the sediments and that sustain oxygen levels high enough for cutaneous (skin) respiration. Little effort has been dedicated to studying these movement corridors and timing. Making sure these travel corridors are maintained and available will enhance annual recruitment and prevent breeding sites from becoming population sinks.

5.3 Avoid management activities that enhance habitat for non-native aquatic predators.

Non-native aquatic predators (e.g., game fish and bullfrogs) occur in close proximity to Oregon Spotted Frog breeding areas. The reason these predators have not colonized Oregon Spotted Frog breeding habitat is unknown but likely has to do with the seasonal nature of water inundation in these areas. Modifications that create more permanent waters, while possibly enhancing summer habitat for Oregon Spotted Frogs, may encourage colonization by non-native predators. Therefore, management actions to improve habitat for the species should be approached with caution.

5.4 Influence management and protection of Oregon Spotted Frog habitat.

5.4.1 <u>Develop site management plans that include site assessments and management actions needed to meet recovery criteria</u>.

WDFW Wildlife Area Management Plans identify management needs and guide management activities on wildlife areas. The plans are updated every two years. Wildlife Management Plans for WDFW Wildlife Areas that occur in a drainage occupied by Oregon Spotted Frogs should be updated to include habitat management prescriptions and direction that will maintain the habitat needs of spotted frogs. WDFW Wildlife Areas with suitable habitat are also potential sites for reintroduction and establishment of new Oregon Spotted Frog populations.

5.4.1.1 Update the South Puget Sound Wildlife Area Management Plan (WDFW 2006) to address management actions needed to meet recovery criteria.

The South Puget Sound Wildlife Area Management Plan addresses management of West Rocky Prairie where Oregon Spotted Frogs are known to occur (Beaver Creek occurrence) and the Black River Wildlife Area where spotted frogs may occur. Long-term control of reed canarygrass needs to be addressed at West Rocky Prairie. Currently, reed canarygrass control at the site is limited to mowing and is done in conjunction with a habitat research study evaluating the effectiveness of mowing on oviposition habitat selection and population size. On-going or long-term management to maintain Oregon Spotted Frog habitat has not yet been addressed, but should be included in the updates to the plan. Recommendations for the Black River Wildlife Area include surveys for Oregon Spotted Frogs. If Oregon Spotted Frogs are discovered, then management should address ways to provide and maintain more breeding habitat through shrub and reed canarygrass control.

5.4.2 Review local and agency land use plans and recommend measures to protect Oregon Spotted Frogs and their habitats especially in the watersheds where the species is documented to occur.

Assist local governments to fulfill the intent of the Growth Management Act for conservation of endangered species including the Oregon Spotted Frog. City and county land use plans or critical wildlife habitat designations provide one tool for achieving these landscape objectives.

5.4.3 Work with public and private landowners to conserve Oregon Spotted Frogs on their lands.

Work with landowners to coordinate and cooperate on habitat management activities important for conservation of Oregon Spotted Frogs. Update the Department's Priority Habitat and Species recommendations for Oregon Spotted Frog and update maps to include all habitats used by Oregon Spotted Frogs including the seasonally flooded wetland margins critical to the species. Engage private landowners of wetland and marsh habitats as conservation partners.

For NRCS projects in drainages occupied by Oregon Spotted Frogs, WDFW should work with NRCS and the landowner on habitat enhancement projects to take into account the habitat needs of Oregon Spotted Frogs. This is especially true for projects that may inadvertently negatively impact spotted frog habitat such as projects that include extensive planting of woody vegetation in pastures and other grass-dominated habitats on the edges of perennial wetlands.

5.4.4 Establish protection and conservation of Oregon Spotted Frogs through conservation agreements, conservation easements, land purchase, land exchange, and charitable donation.

Contact landowners with potentially occupied habitat or habitat suitable for recovery efforts to determine if they are willing to allow survey and/or have Oregon Spotted Frogs established on their land. Investigate offers of potential reintroduction sites by interested landowners. Pursue funds for land acquisition from willing landowners through sources such as the Washington State Recreation and Conservation Office competitive Washington Wildlife and Recreation Program grant program, Endangered Species Act (ESA), Section 6 funds, land trusts, Center for Natural Lands

Management, or other sources and partners. Acquire important parcels as opportunities arise.

In drainages occupied by Oregon Spotted Frogs, WDFW should coordinate with NRCS and land trusts on properties where conservation agreements and conservation easements require cessation of cattle grazing. For such sites, a management strategy for maintaining short vegetation in the seasonally flooded wetlands should be in place before cattle are removed in order to maintain spotted frog breeding habitat. Former pasture lands under agreements that were acquired recently (≤ 5 years) should also be surveyed to determine if spotted frogs are present.

WDFW can provide assistance to landowners to identify programs available for conservation of Oregon Spotted Frogs. A conservation tool available for at-risk and Candidate Species is the Candidate Conservation Agreement and Candidate Conservation Agreement with Assurances (CCAA). Candidate Conservation Agreements encourage conservation actions for species that are candidates for listing as threatened or endangered, or are likely to become candidates. CCAAs may benefit landowners in several ways. For instance, if the actions preclude listing, the landowner is not regulated by the Endangered Species Act. Also for landowners who want to conserve the species or want to manage habitat on their land, an Agreement provides an avenue to potential federal or state cost-share programs.

USFWS intends to complete the status review for the Oregon Spotted Frog in 2013. If the Oregon Spotted Frog is added to the Federal List of Endangered and Threatened Wildlife and Plants, then new incentives will be available to private and other non-Federal property owners. One example is Safe Harbor Agreements (SHA). A SHA is a voluntary agreement involving non-Federal property owners whose actions contribute to the recovery of species listed under the ESA. Participating property owners receive formal assurances from the Service that if they fulfill the conditions of the SHA, the Service will not require any additional or different management activities by the participants without their consent. In additional, at the end of the agreement period, participants may return the enrolled property to the baseline conditions that existed at the beginning of the SHA.

5.4.5 Coordinate Oregon Spotted Frog management activities with management for Sandhill Cranes at Conboy Lake National Wildlife Refuge and Trout Lake Natural Area Preserve.

Oregon Spotted Frogs and Sandhill Cranes co-occur at Conboy Lake and Trout Lake. Cattle grazing, haying, and mowing can benefit both species by maintaining meadows (Littlefield and Ivey 2002). However, mowing of meadows in late June and July can kill crane chicks as they hide in dense vegetation (Littlefield and Ivey 2002). Winter livestock grazing of wetlands generally removes residual cover leaving crane nests exposed to predators in April and May (Littlefield and Ivey 2002). Spring grazing (10 April to 15 July) can prevent nesting attempts and trample chicks (Littlefield and Ivey 2002).

Exclude livestock during the crane's spring breeding season. Hay harvest and grazing should be delayed until after 10 August and grazing should be terminated by March (Littlefield and Ivey 2002). Some undisturbed vegetation patches should be left for nesting. Areas with intense predation pressures may require leaving larger areas of vegetation. These patches of vegetation may also benefit Oregon Spotted Frogs by providing cover.

6. Research to facilitate and enhance recovery.

Causes of the ongoing declines, even at protected sites, remain in the forefront of the knowledge gap for this species. Knowledge is lacking on mechanisms that underlie patterns of distribution at the remnant sites. Research is needed to determine best land management practices, especially involving cattle grazing and reed canarygrass control. Site specific information is also needed on aquatic connectivity and seasonal movement patterns as well as active season and overwintering habitat use.

The cryptic nature of juvenile and adult frogs is problematic for summer inventory work and for attempts to learn more about the life history and movements of these life stages. Research that elucidates when frogs are surface active would enhance inventory and research work (Pearl et al. 2009b). Species detection using environmental DNA (eDNA) from water samples needs to be investigated (Santosa 2001, Ficetola et al. 2008).

To better understand and sustain population viability, effective population sizes (N_e) need to be determined and a viability assessment should be developed. Captive rearing and release activities are in their infancy with much still to be learned. Lastly, more empirical studies are needed to support assumptions based on anecdotal information. This research will be important for supporting adaptive management strategies at each occupied site.

6.1 Determine essential habitat and connectivity corridors at each occupied site.

This information is critical for understanding how to best manage each population. Radio-telemetry and mark-recapture studies have been used successfully on the Dempsey Creek population to determine habitat use, movement corridors, and connectivity between areas that are important during the summer drought (Watson et al. 2003). Understanding the species' vulnerabilities to hypoxia, freezing, and predators during the winter are important for sustaining breeding adults. Molecular genetics methods are particularly suited to quantifying the influence of habitat structure across large spatial extents on gene flow and population connectivity (Cushman 2006) and should be investigated.

6.2 Determine minimum habitat patch size and complexity necessary to support an Oregon Spotted Frog population.

As recommended in Pearl and Hayes (2004), these factors may aid the development of a predictive Oregon Spotted Frog habitat suitability model. This information is important both for understanding remnant Oregon Spotted Frog populations, as well as for reintroduction efforts. Habitat patch size and complexity must be large enough to support a population that will not be prone to inbreeding depression or extirpation due to random demographic events.

6.3 Identify and evaluate the most effective methods of maintaining suitable breeding habitat.

6.3.1 <u>Determine most effective methods of controlling reed canarygrass</u>.

Continue research efforts currently underway at Black River and Trout Lake population complexes to evaluate the effectiveness of grazing, mowing and ‘cut and cover’ methods for controlling reed canarygrass. Keep abreast of what other land management agencies and organizations are doing to manage reed canarygrass.

6.3.2 Evaluate effectiveness of introduced beaver colonies in maintaining Oregon Spotted Frog habitat.

6.3.3 Determine best management practices for sites that use livestock grazing to maintain suitable Oregon Spotted Frog habitat.

Determine the timing and intensity of livestock grazing that best benefits Oregon Spotted Frogs. Determine how to minimize negative habitat impacts, especially those related to degraded water quality.

6.4 Determine best water management practices for Oregon Spotted Frogs at Conboy National Wildlife Refuge.

Hydrology issues were identified by Hayes et al. (2000) as the most significant management challenge for Oregon Spotted Frog conservation at Conboy National Wildlife Refuge. Water management is complicated by lack of knowledge regarding requirements of the frogs, especially the tadpoles, and needs of adjacent land owners who require water (or lack of water) for agriculture. For the long-term, the lack of upstream storage capacity must be addressed, especially related to predicted climate changes. Research to understand the relationship between hydrology and Oregon Spotted Frog survival is necessary, especially as it pertains to minimum water requirements needed for successful reproduction and recruitment. Hayes et al. (2000) provided a list of recommendations for future monitoring and research efforts related to hydrology.

6.5 Determine the impact that amphibian chytrid fungus has on Oregon Spotted Frog populations.

Continue research underway to determine the impact of amphibian chytrid fungus on the Oregon Spotted Frog. Research is needed on virulence, transmissibility, persistence, and interactions with other stressors to assess the potential impact of this disease and what governs susceptibility (Pearl et al. 2007). This is important for determining the amount of resources and time that should be dedicated to investigation of this disease.

6.6 Determine feasibility of environmental DNA (eDNA) methodology for Oregon Spotted Frog inventory and early detection of invasive species.

The ability to inventory Oregon Spotted Frogs has been hampered by the difficulty of detection during certain seasons. Recent work has shown that primers can be used to amplify short mitochondrial DNA sequences that persist in the aquatic environment (environmental DNA = eDNA) to detect the presence of a species in a water body (Santosa 2001, Ficetola et al. 2008). Ficetola et al. (2008) were able to detect bullfrogs in all environments where they were present, even when the species was at low densities. This method allows for detection of secretive species without direct observation, assessment of the distribution of rare species and detection of invasive species at the early stages of invasion (Ficetola et al. 2008).

6.7 Determine effective population size (N_e), estimate minimum viable population size and develop a viability assessment.

6.7.1 Determine the effective population size (N_e) of each population in Washington.

The effective population size (N_e) is the number of individuals in a population that contribute offspring to the next generation and is related to population viability. As summarized by Funk et al. (1999), knowing N_e is important for the following reasons: 1) the relative N_e values of different populations can be used to predict extinction risk; 2) examining changes in N_e over time can determine whether populations are declining; and 3) N_e values can be used to determine whether genetic factors (e.g., inbreeding depression) are involved in declines. This information should be used to refine the recovery objectives, if needed.

6.7.2 Identify and collect population or genetic data needed to estimate minimum viable population and develop a minimum viable population estimate for the Oregon Spotted Frog.

6.8 Determine the relationship between environmental conditions and surface activity.

Oregon Spotted Frogs absorb oxygen and emit carbon dioxide through the skin (cutaneous respiration) as well as the lungs. Using cutaneous respiration, they can remain completely submerged during periods when dissolved oxygen levels remain high enough to meet their respiratory needs. During these periods, the frogs are difficult to detect during visual survey work. Research that elucidates the conditions under which Oregon Spotted Frogs are surface active would enhance inventory and life history research.

6.9 Continue development of captive rearing techniques.

Continue efforts started in 2007 by the Woodland Park Zoo, Oregon Zoo, Northwest Trek Wildlife Park, and Cedar Creek Corrections Center (in cooperation with The Evergreen State College) to develop and standardize husbandry techniques for raising Oregon Spotted Frogs from egg masses.

6.10 Determine habitat features or population characteristics that contribute to Oregon Spotted Frog persistence with non-native fish and American Bullfrogs.

The possibility that bullfrogs or non-native game fish will be eliminated by management is slight; therefore, Oregon Spotted Frog populations must be managed for coexistence (Adams and Pearl 2007). This is especially true for lowland Puget Sound where most large wetland complexes are likely to have at least one non-native predator. Determining how the population of Oregon Spotted Frogs at Conboy Lake persists in the presence bullfrogs and Brown Bullheads is important toward this goal. It is also important to understand how to help constrain non-native predators to low numbers.

7. Establish information management systems and provide for information sharing.

7.1 Maintain centralized repository for monitoring data.

The WDFW corporate database (WSDM) has a staff person with responsibilities for entering amphibian and reptile data. Continue maintaining Washington's Oregon Spotted Frog data in the WDFW system and update with annual survey results.

7.2 Produce an annual report summarizing egg mass census trends and management actions.

7.3 Facilitate an information exchange network.

Some of this role is being fulfilled currently by the Oregon Spotted Frog Working Group of Washington. The group currently meets annually and subgroups meet more often as needed to address specific Oregon Spotted Frog conservation issues. Similar working groups have also been established in Oregon and Canada. Meetings should continue at least annually for information exchange and consultation.

8. Develop public information and education programs.

Many people are aware and concerned about the worldwide decline of frogs. However, many Washington citizens may be unaware that a frog in their own "backyard" is facing the same fate. Providing informational material to highlight the plight of Oregon Spotted Frogs will increase the social value of this species and will assist in gaining public support for its conservation. Protection of Oregon Spotted Frog habitat will also benefit the conservation of wetlands and associated flora and fauna.

8.1 Enhance public awareness of Oregon Spotted Frog status and conservation activities.

8.1.1 <u>Produce news releases, public service announcements and articles for newspapers and magazines.</u>

8.1.2 <u>Disseminate fact sheets, pamphlets, and other educational tools</u>.

Pamphlets, fact sheets, and websites have been produced by WDFW to raise awareness and assist with education. Production and dissemination of these materials should be expanded. Distribution should coincide with media events and other outreach by the department.

8.1.3 <u>Maintain the Oregon Spotted Frog information on the on-line Washington Herp Atlas</u>.

Keep the Oregon Spotted Frog account updated and use this website for outreach and to request information from the public.

8.1.4 Encourage the NW Zoo & Aquarium Alliance to continue the outreach endeavors initiated in 2008 that include media releases and educational materials at Washington's zoos and aquariums.

8.1.5 Update information about Oregon Spotted Frog recovery on the WDFW website and provide information to federal and state agencies, as well as zoos, for their websites.

8.1.6 Engage amphibian conservation groups, such as the Northwest Partners in Amphibian and Reptile Conservation (NW PARC), to assist with outreach and education regarding the Oregon Spotted Frog.

8.1.7 Complete the Wikipedia Oregon Spotted Frog Wiki with information on Washington recovery activities and keep the Wiki updated.

8.1.8 Use social media to update the public about Oregon Spotted Frog recovery efforts.

8.1.9 Distribute a one page fact sheet every January as a reminder to people doing outdoor activities to watch for the species while conducting inventory and research during the year.

8.2. Facilitate activities that promote the social value of the Oregon Spotted Frog.

8.2.1 Support plans by Woodland Park Zoo to create an Oregon Spotted Frog exhibit that features live frogs.

8.2.2 Allow the public to follow annual events in the life of Oregon Spotted Frogs with the use of WDFW's WildWatch.com, YouTube, Twitter, and Facebook.

8.3 Develop educational material and participate in educational programs.

8.3.1 Develop an educational packet for teachers with background information on the Oregon Spotted Frog. Use this in conjunction with the social media activities.

8.3.2 Develop an Oregon Spotted Frog poster.

Highlight the life cycle with information on habitat and status, as well as information on how to distinguish it from the other native ranid frogs. Distribute these to educators, especially those within the historical range of the Oregon Spotted Frog or areas of interest for reintroduction.

8.3.3 Encourage speakers knowledgeable about Oregon Spotted Frogs to make presentations to schools and nature centers near areas with potential Oregon Spotted Frog habitat.

8.3.4 Develop and distribute materials discouraging introduction of non-native flora and fauna that may be detrimental to Oregon Spotted Frogs and their habitat.

9. Coordinate and cooperate with public agencies, landowners, and non-governmental organizations and secure funding sources for recovery efforts.

9.1 Form working groups as needed to implement recovery actions.

9.2 Work with land trusts and other groups conserving wetlands within the recovery zones.

9.3 Work with private landowners in the Glenwood Valley to develop solutions for Oregon Spotted Frog recovery at Conboy Lake, especially those issues related to water use.

9.4 Secure funding for recovery activities.

9.4.1 Secure federal, state, and non-governmental foundation grants to conduct research, reintroductions, and other recovery activities.

9.4.2 Develop partnerships to secure funding for recovery activities including land acquisition, purchase of development rights and habitat maintenance needs over time.

10. Coordinate and cooperate with Washington's tribes on Oregon Spotted Frog recovery through Government-to-Government consultations.

Seventeen tribes have lands within the historical range of the Oregon Spotted Frog in Washington. Tribal governments manage wildlife on their reserved lands. The Yakama Nation is located in the East Cascades Ecoregion and may have suitable habitat for Oregon Spotted Frogs on tribe-owned lands. Sixteen tribes have reserved and ceded lands in the Puget Sound Ecoregion.

11. Periodically review and revise Washington recovery and conservation planning documents for the Oregon Spotted Frog.

IMPLEMENTATION SCHEDULE

Identified below are the agencies, WDFW involvement, task priorities and estimates of annual expenditures needed for Oregon Spotted Frog recovery (Table 4). Cost estimates do not mean that funds have been designated or are necessarily available to complete recovery tasks. **Implementation of recovery strategies is contingent upon availability of sufficient funds to undertake recovery tasks.**

The following conventions are used:
Priority 1: Actions needed to prevent the extinction of the species in Washington.
Priority 2: Actions to monitor the population and prevent a significant decline in population size or habitat quality, or some other significant negative impact short of extirpation.
Priority 3: All other actions necessary to meet recovery objectives.

Acronyms

BLM	Bureau of Land Management (Oregon)
CCCC	Cedar Creek Correctional Center
CCT	Chehalis Confederated Tribe
CTBYN	Confederated Tribes and Bands of the Yakama Nation
JBFM	Joint Base Lewis-McChord
CNLM	Center for Natural Lands Management
LT	Land Trusts
NT	Nisqually Tribe
NWPARC	Northwest Partners in Amphibian and Reptile Conservation
NWT	Northwest Trek
OZ	Oregon Zoo
PBTF	Port Blakely Tree Farm
PDZA	Point Defiance Zoo and Aquarium
PL	Private landowners
TESC	The Evergreen State College
TG	Tribal governments
UR	University researchers
USFS	USDA U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey (Oregon)
VO	Volunteer organizations
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington Department of Natural Resources
WOSFWG	Washington Oregon Spotted Frog Working Group
WLT	Whatcom Land Trust
WPZ	Woodland Park Zoo

Table 5. Implementation schedule and preliminary cost estimates for implementation of the Washington Recovery plan for Oregon Spotted Frog.

Priority	Recovery Task	Duration in years	Potential Cooperators	Est. Annual Cost ($1,000's)	WDFW share
2	1.1 Conduct annual egg mass census.	annually	WDFW, USFWS, WDNR, PBTF, CNLM, USFS, VO, WLT		
2	1.2 Monitor larval development and dispersal.	ongoing	WDFW, USFWS, WDNR, PBTF, USFS		
3	1.3 Document monitoring methods and develop a standardized monitoring protocol.	< 1	WDFW, USFWS, PBTF, USFS		

Priority	Recovery Task	Duration in years	Potential Cooperators	Est. Annual Cost ($1,000's)	WDFW share
3	2.1 Augment knowledge about historical distribution.	1	WDFW		
3	2.2 Create a model of historically and potentially occupied habitats.	1	WDFW		
3	2.3 Develop inventory methodology to determine occupancy and absence.	1	WDFW, USGS, USFWS, BLM, USFS		
3	2.4 Develop isoline map of Oregon Spotted Frog breeding phenology.	< 1	WDFW		
3	2.5 Expand inventory efforts.	ongoing	WDFW, USFWS, WDNR, USFS, PL, CCT, CTBYN, NT, CNLM, LT VO, WLT		
1	3.1 Facilitate survival.	ongoing	WDFW, USFWS, WDNR, USFS, PBTF, PL, WLT		
2	3.2 Prevent introductions of non-native predatory species.	ongoing	WDFW, USFWS, WDNR, PBTF, USFS, PL, WLT		
2	4.1 Establish new Oregon Spotted Frog populations.	ongoing	WDFWUSFWS, CNLM, , USFS, TG, PL, JBLM, UR		
3	4.2 Monitor frogs at translocation and reintroduction sites.	5-10	WDFW, USFWS, CNLM, PL, JBLM, UR, USFS		
3	4.3 Evaluate success of translocation and reintroduction sites.	≤1	WDFW, WOSFWG		
1	5.1 Maintain early successional vegetation structure at breeding areas.	ongoing	USFWS, WDNR, WDFW, PBTF, JBFM, USFS, PL, WLT		
1	5.2 Maintain connectivity between breeding areas and permanent water.	ongoing	USFWS, WDNR, WDFW, PBTF, JBFM, USFS, PL, WLT		
2	5.3 Avoid management activities that enhance habitat for non-native aquatic predators.	ongoing	USFWS, WDNR, WDFW, PBTF, JBFM, USFS, PL, WLT		
2	5.4 Influence management of Oregon Spotted Frog habitat.	ongoing	WDFW, USFWS, WDNR, PBTF, JBFM, USFS, PL, WOSFWG, WLT		
1	6.1 Determine essential habitat and connectivity corridors at each extant site.	5	WDFW, USFWS, WDNR, PBTF,USFS, WLT		
3	6.2 Determine minimum habitat patch size and complexity necessary to support Oregon Spotted Frog population.	5	WDFW, USFWS, USFS		
2	6.3 Identify and evaluate the most effective methods of maintaining suitable breeding habitat.	5	WDFW, USFWS, USFS. PBTF, USGS, BLM, USFWS, UR, WDNR		
2	6.4 Determine best water management practices for Oregon Spotted Frog at Conboy National Wildlife Refuge.	5	USFWS, WDFW		
3	6.5 Determine the impact that amphibian chytrid fungus has on Oregon Spotted Frog populations.	5	WDFW, UR		
3	6.6 Determine feasibility of eDNA methodology for Oregon Spotted Frog inventory and early detection of invasive species.	3	WDFW, USFWS, USFS, BLM, USGS		
3	6.7 Determine effective population size (N_e), estimate minimum viable population size and develop a viability assessment.	1	WDFW, USFWS, BLM, USGS, USFS		
3	6.8 Determine relationship between	2	WDFW, USFWS, UR		

Priority	Recovery Task	Duration in years	Potential Cooperators	Est. Annual Cost ($1,000's)	WDFW share
	environmental conditions and surface activity.				
3	6.9 Continue development of captive rearing programs.	ongoing	CCCC, NWT, OZ, PSZA, WPZ, MVCP, WDFW		
2	6.10 Determine habitat features or population characteristics that contribute to Oregon Spotted Frog persistence with non-native fish and American Bullfrogs.	5	WDFW, USFWS, USFS, BLM, USGS		
3	7.1 Maintain centralized repository for monitoring data.	ongoing	WDFW		
2	7.2 Produce an annual report summarizing egg mass census trends and management actions.	annually	WDFW, WDNR, USFWS, PBTF, USFS		
2	7.3 Facilitate an information exchange network.	< 1	WDFW, USFWS		
3	8.1 Enhance public awareness of Oregon Spotted Frog status and conservation activities.	ongoing	WDFW, NWPARC, NWT, OZ, PDZA, TESC, CNLM, LT, USFWS, WDNR, WPZ		
3	8.2 Facilitate activities that promote the social value of the Oregon Spotted Frog.	ongoing	WDFW, NWPARC, NWT, OZ, PDZA, TESC, CNLM, LT, USFWS, WDNR, WPZ		
3	8.3 Develop education material and participate in educational programs.	ongoing	WDFW, NWPARC, NWT, OZ, PDZA, TESC, CNLM, LT, USFWS, WDNR, WPZ		
3	9.1 Form working groups as needed to implement recovery actions.	ongoing	WDFW, WOSFWG		
3	9.2 Work with land trusts and other groups conserving wetlands within the recovery zones.	ongoing	WDFW		
2	9.3 Work with private landowners in the Glenwood Valley to develop solutions for Oregon Spotted Frog recovery at Conboy Lake, especially those issues related to water use.	10	WDFW, USFWS, PL		
2	9.4 Secure funding for recovery activities.	ongoing	WDFW, USFWS, USFS		
3	10.0 Government to government coordination and cooperation.	ongoing	WDFW, TG		
3	11.0 Review and revise Washington recovery and conservation documents periodically.	Every decade	WDFW		

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APPENDIX A. EGG MASS CENSUS DATA FOR OREGON SPOTTED FROGS AT THE BLACK RIVER, CONBOY LAKE AND TROUT LAKE POPULATION COMPLEXES.

Table A1. Number of egg masses found at Black River population complex, 1996-2012.

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Dempsey Creek																	
The Forbes[1]	169	125	83	181	222	159	124	150	186	173	138	192	170	238	235	129	93
Musgrove[2]													0	8	49	37	18
The Dairy Farm[3]			37	2						3				54	100	54	6
Stony Creek[5]						28				17			36				
Dempsey headwaters[1]											8						
Pipeline[4]								94	108				64	15	0	36	19
Salmon Creek[6]															27	58	96
Blooms Ditch (110th)[7]						4	2	0	1	1		0	0	0	0		
Black River (123rd)[8]						32	10	32	127	5	2	98	384*	685	574	591	480
Beaver Creek[9]				28	123	59					61		26	66	76	45	77
Allen Creek[10]													≥ 25	15	76	246	85

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* Increased survey effort starting in 2008 at 123rd.

Table A2. Number of egg masses found at Conboy Lake population complex, 1998-2012.

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
All occupied units (17)	7,018	5,434	4,666	1,630	1,442	2,085	3,898	3,404				1,435	1,706	1,404	977
Subset occupied units (4)[2]						1,163	1,271	998	511	444	< 500	781	583	502	324

[1] 1998-2005, M. Hayes and J. Engler, as summarized in USFWS (2009); 2006-2008, M. Hayes as summarized in USFWS (2009); 2009-2012, M. Hayes, pers. comm.[2] The four occupied units sampled throughout the time series are C&H, Conboy Lake, Laurel West and Troh.

Table A3. Number of egg masses found at Trout Lake population complex, 1997-2012.

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
East Marsh																
North, middle & south	289	432	388	606	277	182	232	157	174	144	196	135	258	503	477	582
Interior					43	88			135			58	169	73	42	99
West Side																
Elk Meadows	125	179	183	185	66	139	154	108	102	75	12	52	49	78	120	110
Clarksville	156	245	193	168	126	103	93	84	72	36	0	15	38	43	20	41
USFS Beaver Pond	2				117		60		85					22	16	0
SDS Pond					16						9	17	28	26	24	21
NAP Beaver Pond (N. Wetland)											50	35	39	47	50	46
North Pond														30	22	25
Southeast														14	4	8
Tree Snag														≥ 111	147	130

1997 data from Leonard (1997); 1998-1999 data collected by W.P. Leonard and L. Hallock; 2000 and 2002-2012 data collected by L. Hallock; and 2001 data collected by J. Lewis and S. VanLeuven (pers. comm.).

APPENDIX B. PRECIPITATION RECORDED AT MT. ADAMS RANGER STATION, TROUT LAKE, WASHINGTON.

Precipitation data came from Mt. Adams Ranger District weather station located about a half mile from the southern portion of Trout Lake wetland in Trout Lake. Data was provided by J. Ashby (climatologist at Division of Atmospheric Science, Nevada System of Higher Education, Reno) and is also available on-line at www.wrh.noaa.gov/pdt. Weather data has been collected at this weather station since 1925. Precipitation, if measured correctly, includes all rain and melted snowfall. The data available had missing days where precipitation data was not taken. According to J. Ashby, the reason for missing data days appears to be that the observers for the Mt. Adams Ranger District did not take observations on a daily basis (perhaps no weekends or holidays) but take the accumulated total over the days they were gone. According to B. Coffin (Mt. Adams Ranger Station) in recent times the process is automated using a Fisher & Porter Gauge that records scale weights of the precipitation cylinder by punching holes into special graph paper. Possible reasons for missed data days include automated rain gage paper tape jams, snowbridge over cylinder, or failure to empty full cylinder. Coffin is alerted by NOAA when readings are not being properly recorded so the situation can be corrected. All people contacted, including a representative from NOAA National Weather Service in Pendleton, Oregon, reported that small gaps in recording should not be of concern and are likely captured in sequential checks.

Table B1. Monthly precipitation recorded 1997-2009 and total average precipitation recorded 1971-2000 at Mount Adams Ranger Station, Trout Lake, Washington.

Year	Month												Total (in.)
	Jan	**Feb**	**Mar**	**April**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	
1997	4.01 c[3]	1.62 b	8.28h	3.60i	1.31a	1.71	0.19	1.47a	4.62c	10.63b	7.83h	3.65	48.92
1998	5.56i	9.9h	4.39e	1.66b	3.44c	1.07	0.15	0.03	1.25	2.43a	13.89g	11.11f	54.92
1999	9.76g	12.21g	7.51j	0.70d	1.22f	0.15	0.12	2.41	0.05	2.96a	11.93f	6.62b	55.64
2000	8.83n	4.97k	1.14b	0.28	2.18f	2.41	0	0	0.86	2.21f	2.58	1.50g	26.96
2001	1.57c	0.69b	.75d	1.75b	2.51d	1.72	0.43	1.13	0.33	4.33	8.16g	8.07j	31.44
2002	9.33i	3.83g	7.15e	2.48c	1.00g	1.44	0.00z	0.03	0.17	.03e	3.64b	9.56j	38.66a
2003	8.431	3.02h	10.04d	2.96c	.81e	0	0	0.15	0.00z 0.34[4]	3.07c	4.99g	4.65j	38.12- 38.46[4]
2004	3.65i	1.28e	3	0.00c	3.03b	1.63	0.2	2.52	2.49	3.06b	1.47c	3.15f	25.48
2005	2.04c	1.33d	5.31d	2.41c	4.13c	0.77	0.28	0	0.68	3.52b	6.84e	4.49d	31.8
2006	13.15h	2.01a	3.49c	2.53b	2.12a	1.88	0.5	0	.41a	.92a	19.80f	3.05h 9.05[4]	55.86- 61.86[4]
2007	4.40e	6.15d	2.97d	1.53b	0.57	0.23	0.4	0.8	0.03	5.13c	6.73d	11.85h	40.79
2008	7.29e	2.34f	3.51b	0.00z 1.40[4]	0.88b	1.34	0.05	1.12	0.04a	2.18d	6.42e	5.08g	30.25- 31.65[4]
2009	4.3d	2.46i	4.54h	1.58b	4.67	0.87	0.00z	.33a	1.27a	3.14h 3.49[4]	9.23g	3.08q 5.60[4]	35.47a - 38.34[4]
Total Ave.[2] 1971-2000	**7.00**	**6.13**	**4.67**	**2.50**	**1.59**	**1.07**	**0.45**	**0.72**	**1.51**	**3.05**	**6.94**	**7.12**	**42.74**

[1] Monthly precipitation recorded 1997-2009, provided by J. Ashby, Staff Service Climatologist, Division of Atmospheric Science, Nevada System of Higher Education, Reno, Nevada.
[2]Total average precipitation 1971-2000, from NOWData, NOAA Online Weather Data Http://nowdata.rcc-acis.org/PDT/pubACIS_results.
[3]Indicates missing days when data was not recorded: a = 1 day, b = 2 days and so forth.
[4]Data provided by J. Ashby (top) vs. data available on-line www.wrh.noaa.gov/pdt.climate (bottom)

Table B2. Monthly precipitation recorded October to March 1997-2009 at Mount Adams Ranger Station, Trout Lake, Washington highlighting the dramatic drop in precipitation during those months 2000-2001 and 2004-2005.

Year	***Month***						
	Oct	**Nov**	**Dec**	**Jan**	**Feb**	**March**	**TOTAL (in.)**
1997-1998	10.63	7.83	3.65	5.56	9.94	4.39	42
1998-1999	2.43	13.89	11.11	9.76	12.21	7.51	56.91
1999-2000	2.96	11.93	6.62	8.83	4.97	1.14	36.45
2000-2001	2.21	2.58	1.5	1.57	0.69	0.75	9.3
2001-2002	4.33	8.16	8.07	9.33	3.83	7.15	40.87
2002-2003	0.03	3.64	9.56	8.43	3.02	10.04	34.72
2003-2004	3.07	4.99	4.65	3.65	1.28	3	20.64
2004-2005	3.06	1.47	3.15	2.04	1.33	5.31	16.36
2005-2006	3.52	6.48	4.49	13.15	2.01	3.49	33.14
2006-2007	0.92	19.8	9.05	4.4	6.15	2.97	43.29
2007-2008	5.13	6.73	11.85	7.29	2.43	3.51	36.94
2008-2009	2.18	6.42	5.08	4.3	2.46	4.54	24.98
2009-2010	3.14	9.23	3.08	--	--	--	--
Total Ave.[2] 1971-2000	**3.05**	**6.94**	**7.12**	**7.00**	**6.13**	**4.67**	**34.91**

Data provided by J. Ashby, Staff Service Climatologist, Division of Atmospheric Science, Nevada System of Higher Education, Reno, Nevada.

Table B3. Annual precipitation recorded at Mt. Adams Ranger Station 1925-2009 (85 years).

Year	**Precip. ≤ 30 in.**	**Year**	**Precip. 31-40 in.**	**Year**	**Precip. 41-50 in.**	**Years**	**Precip. 51-60 in.**	**Year**	**Precip. > 60 in.**
1944	22.53	2001	31.44	2007	40.76	1946	52.02	1961	60.97
1976	23.25	2005	31.8	1926	40.87	1971	52.4	1951	61.89
2004	25.48	1952	31.92	1960	41.06	1931	52.94	1983	64.03
1929	26.78	1959	31.94	1986	41.22	1995	53	1933	68.78
2000	26.96	1957	32.12	1990	41.25	1972	53.57	1950	75.64
1930	28.16	1989	32.13	1973	41.65	1954	54.28		
1985	28.53	1993	33.21	1967	41.73	1998	54.92		
1948	28.69	1965	34.55	1988	42.14	1982	55.04		
1935	28.92	1975	35.45	1974	42.31	1999	55.64		
1978	30.06	2009	35.47	1987	42.55	2006	55.86		
2008	30.25	1980	35.58	1956	42.96	1945	56.43		
		1939	35.88	1969	43.45	1934	57.32		
		1979	36.25	1970	45.3	1968	58.4		
		1958	36.43	1928	46.08	1955	58.55		
		1981	36.95	1949	46.28	1953	59.43		
		1943	36.98	1964	46.76	1937	59.49		
		1994	37.11	1962	47.12				
		1991	37.27	1941	47.53				
		1963	37.55	1932	47.82				
		1925	37.76	1940	48.43				
		1984	37.87	1966	48.51				
		1938	37.99	1997	48.92				
		2003	38.12	1942	48.93				
		1992	38.35	1927	49.25				
		2002	38.66	1996	49.89				
		1947	39.1						
		1936	40.26						

Data provided by J. Ashby, Staff Service Climatologist, Division of Atmospheric Science, Nevada System of Higher Education, Reno, Nevada.

WASHINGTON STATE STATUS REPORTS AND RECOVERY PLANS

Status Reports

2007	Bald Eagle	√
2005	Mazama Pocket Gopher, Streaked Horned Lark, and Taylor's Checkerspot	√
2005	Aleutian Canada Goose	√
2004	Killer Whale	√
2002	Peregrine Falcon	√
2000	Common Loon	√
1999	Northern Leopard Frog	√
1999	Olympic Mudminnow	√
1999	Mardon Skipper	√
1999	Lynx Update	
1998	Fisher	√
1998	Margined Sculpin	√
1998	Pygmy Whitefish	√
1998	Sharp-tailed Grouse	√
1998	Sage-grouse	√
1997	Aleutian Canada Goose	√
1997	Gray Whale	√
1997	Olive Ridley Sea Turtle	√
1997	Oregon Spotted Frog	√
1993	Larch Mountain Salamander	
1993	Lynx	
1993	Marbled Murrelet	
1993	Oregon Silverspot Butterfly	
1993	Pygmy Rabbit	
1993	Steller Sea Lion	
1993	Western Gray Squirrel	
1993	Western Pond Turtle	

Recovery Plans

2012	Sharp-tailed Grouse	√
2011	Gray Wolf	√
2007	Western Gray Squirrel	√
2006	Fisher	√
2004	Sea Otter	√
2004	Greater Sage-Grouse	√
2003	Pygmy Rabbit: Addendum	√
2002	Sandhill Crane	√
2001	Pygmy Rabbit: Addendum	√
2001	Lynx	√
1999	Western Pond Turtle	√
1996	Ferruginous Hawk	√
1995	Pygmy Rabbit	√
1995	Upland Sandpiper	
1995	Snowy Plover	

√ These reports are available in pdf format on the Department of Fish and Wildlife's web site: http://wdfw.wa.gov/wlm/diversty/soc/concern.htm.
To request a printed copy of reports, send an e-mail to wildthing@dfw.wa.gov or call 360-902-2515.