FINAL REPORT FOR WORK GROUP DISTRIBUTION

2017 Chehalis ASRP
Stream-Associated Amphibian Survey Summary
4th Progress Report for Post-Feasibility Effort (30 June 2017)

Marc Hayes, Julie Tyson & Keith Douville
Washington Department of Fish and Wildlife, Habitat Program
Science Division, Aquatic Research Section

EXECUTIVE SUMMARY: The purpose of stream-associated amphibian surveys was to detect and determine the distribution of Dunn's and Van Dyke's salamanders (*Plethodon dunni* and *P. vandykei*) in the Chehalis headwater landscape in and around the footprint of the potential dam and reservoir. Dunn's and Van Dyke's salamanders are two of non-fish species targeted in the headwater stream-associated guild to examine potential effects of the proposed dam and reservoir on wildlife. This progress report updates the effort, begun in 2014, with data from the 2017 season, the last year for these surveys. Field effort during the 2017 season was completed on 15 June 2017, reflecting an unusually wet winter. This left enough time to develop a basic summary of the 2017 effort, but not its entire analytical portion. Integration of the analytical portion of the complete effort for the entire four years will be part of the final report planned for delivery on 30 September 2017.

We surveyed 30 sites for the 2017 part of this effort, 21 sites were new (not surveyed in any year in the interval 2014-2016). At each site, surveys involved a substrate search of nine 3 m × 5 m terrestrial plots spaced at 5-10 m intervals with their short axis abutting the wetted stream edge. In 2017, we detected 72 Dunn's salamanders at 11 sites, and 98 Van Dyke's salamanders at 14 sites. Five of the Van Dyke's salamander sites were new, the remaining nine sites were resurveyed sites where Van Dyke's salamanders had been found in 2014, 2015, and 2016; these sites were resurveyed to verify their continued presence. Ten of the Dunn's salamander sites were new. The 2017 effort also incidentally recorded 416 individuals representing at least eight additional native amphibian species.

Our 2017 effort reinforced patterns that first began to be revealed in 2015, which are:

1) Van Dyke's salamander detection increases with elevation;

2) Dunn's salamander detection declines somewhat with elevation;

3) Van Dyke's salamander seems rare in the potential footprint of the dam and reservoir;

4) Dunn's salamander seems relatively frequent in the potential footprint of the dam and reservoir.

These patterns, the riparian habitat and life history needs of both salamanders, and the anticipated habitat changes of dam flood control alternatives lead us to conclude that:

1) the permanent reservoir of the FRFA design would eliminate existing habitat for both species, and re-establishment of either species along the "new" riparian margins of the potential FRFA dam/reservoir design is unlikely because of the dynamic seasonal stage of the reservoir and its dynamic effect on the riparian margin;

2) infrequent but uncertain inundation of the potential FRO dam design would eliminate existing habitat at irregular intervals; and re-establishment of either species along the irregularly changing "new" riparian margins is unlikely; and
3) either dam design may have uncertain isolating effects on both species because disruption of stream-margin connections among populations located in tributaries to the Chehalis mainstem is anticipated as the result of permanent (FRFA) or irregular (FRO) reservoir footprint positioning.

In summary, stream-associated amphibian surveys (2014-2017) have sampled 141 unique sites. Collectively, we made observations of 248 Dunn's salamanders at 51 unique sites (36% of all unique sites), and 184 Van Dyke's salamanders at 14 different sites (10% of unique sites). For Dunn's salamander, this included 7 (41%) of 17 sites, 24 (36%) of 66 sites, and 20 (34%) of 58 sites, respectively, below, within, and above the footprint of the potential dam and reservoir. For Van Dyke's salamander, this included 0 (0%) of 17 sites, 1 (2%) of 66 sites, and 13 (22%) of 58 sites across the same categories. Elevation breakdown revealed a sharper difference between the species. We found Dunn's salamander at 30 (39%) of 77 sites, 21 (50%) of 42 sites, and 3 (13.6%) of 22 sites, respectively, at ≤750 ft (229 m), 751 to 1500 ft (229 to 457 m) and >1500 ft (457 m). In contrast, we found Van Dyke's salamander at 1 (1%) of 77 sites, 5 of 42 (12%) sites, and 8 of 22 (36%) sites in the elevation categories. Across all years, we have also incidentally made 1,227 observations of at least 10 additional native amphibian species.

INTRODUCTION: This report summarizes the results of the Chehalis ASRP stream-associated amphibian surveys to date (through 2017 sampling) in headwaters of the Chehalis mainstem that encompasses the vicinity of the proposed footprint of the dam and its reservoir and the adjacent headwater areas. These surveys focus on the terrestrial stream-associated amphibians because Dunn's salamander (*Plethodon dunni*) and Van Dyke's salamander (*P. vandykei*), two of the eight ASRP non-fish aquatic-habitat associated target species, are regarded as stream-associated but occur in the terrestrial riparian habitat immediately adjacent streams. We first initiated stream-associated amphibian surveys on 24 February 2014. This report augments information from surveys completed in 2014, 2015 and 2016. In 2017, surveys began on 30 March and were completed on 15 June 2017. Several years are required to complete an adequate assessment because the time window in which these species (particularly Van Dyke's salamander) are surface active (that is, effectively detectable) in any one year is short (about three months), which limits the number of sites that can be effectively surveyed annually.

SITE SELECTION: We chose sites from a 187-site pool systematically placed along the stream network within the coniferous forest landscape to provide an array dispersed across the footprint of the proposed dam and its reservoir and the surrounding area. When we discuss the footprint of the proposed dam and reservoir, footprint means the reservoir at full pool. Besides the fact that this footprint includes the proposed dam and reservoir area, this footprint was selected based on the coniferous forest landscape being the only Chehalis Basin habitat where Van Dyke's salamander might be expected. As in previous years, we selected sites in this pool at a minimum distance 400 m from one another to ensure independence among sites; the annual movement scale of terrestrial salamanders like Dunn's and Van Dyke's salamanders is <20 m (Ovaska 1988, Staub et al. 1995).

In 2014, we developed an original pool of 128 sites from which to select sites, but increased that pool by 15 new sites later in 2014, by 43 new sites in 2015, by one site in 2016, and by 14 new sites in 2017. One reason for augmenting the site pool was our inability to access selected sites because of washed out roads or because selected sites lacked habitat for sampling (e.g., a bedrock cliff face) or had too little habitat to lay out a sampling array (see Sampling section). This reason led us to reject five sites in 2014, nine sites in 2015, and 25 sites in 2016. The second reason for adding to the site pool was to enable selecting enough sites outside the potential dam and reservoir footprint to understand potentially different patterns of distribution within versus outside of that footprint. We considered the latter critical to characterizing the consequence of potential changes in habitat resulting from the location of a proposed dam/reservoir footprint.

In 2014, we selected sites to be sampled so that about 60% of the sites were from within the proposed dam/reservoir footprint; the remaining about 40% of the sites were selected from above and below the dam/reservoir footprint in a ratio of 9:1 above versus below the reservoir. In 2015 and 2016, we intentionally created the target of 14 sites to be sampled outside of the footprint that were selected in a ratio 11:3 above versus below it. We designed this selection pattern to capture potential differences in species distribution that might occur as a consequence of footprint location when considering the large area of coniferous forest habitat available upstream, which, in some ways, is similar to existing habitat within the footprint. In contrast, coniferous forest habitat was very limited downstream of the footprint. In 2015 and 2016, we intentionally shifted the ratio of sites sampled upstream versus downstream of the proposed dam and reservoir to ensure enough sites would exist downstream to enable effective comparison to other areas. In 2017, we shifted the ratio to intentionally capture higher elevation sites to enable effective elevational comparison. Figure 1 shows both sites available for sampling and sites sampled in 2017; sites sampled in the proposed dam/reservoir footprint are gold ●, those below the footprint are pink ● and those above the footprint are in green ●. Sites in the pool but that we did not select are in white ○.

We had a target minimum number of sites to be sampled each year based on our effective sampling window and field crew size. Our minimum target number of sites was 30 in each of 2015, 2016, and 2017, and 51 in 2014. The greater target number in 2014 was because we had a field crew that we could devote exclusively to this sampling, whereas in 2015-2017, we had to partition crew effort between this sampling that involving other Chehalis tasks. In 2017, our target distribution of sites was one within, 23 above, and six below the potential dam/reservoir footprint. In each of 2015 and 2016, our target distribution of sites was 16 within, 11 above, and three below the potential dam/reservoir footprint; in 2014, our target distribution was 31 within, 18 above, and two below the potential dam/reservoir footprint. Further, in 2017 we resampled the nine sites where Van Dyke's salamanders were found in 2014-2016 surveys to assess whether the species was still present at those sites. During the 2015 and 2016 field seasons, we had similarly resampled the sites where Van Dyke's salamanders in all previous years for the same reason.

SAMPLING: We conducted all surveys with a field crew of at least three with sampling done on four days each week. We surveyed by laying out nine 3 m wide × 5 m long plots at each site, each of which abutted the wetted edge of the stream along their short axis. Sampling was done by raking through the litter (leaves, conifer needles, and small wood debris), rock and soil substrate with a potato rake, overturning movable surface objects, and taking apart woody debris sufficiently decayed to be dismantled. The only exception to the sampling protocol was done in 2017, where we conducted light-touch surveys on the five Van Dyke's salamander locations from 2014 and 2015. These light touch surveys involved moving all movable surface objects up to 5 m upslope from wetted stream edges and along 50-100 m of shoreline. We used this method to minimize the repeated disturbance resulting multiple years of surveys at those sites.

RESULTS: In 2017, we met our planned 30-site survey target, including resurvey of the nine unique sites where Van Dyke's salamanders were found in all previous year collectively (**Table 1**). We also met our target with regard to distribution, as six of the 30 sites were located below the footprint of the potential dam/reservoir, one site was located within the footprint, and 23 sites were located at elevations above the footprint (**Figure 1**). Resurveyed Van Dyke's salamander sites included the only one within the footprint of the potential dam/reservoir and eight above of the footprint.

Table 1. Target site numbers, numbers of sites actually sampled and their distribution relative to the potential dam/reservoir footprint and Van Dyke's sites resurveyed by year. Unique means the total number of different sites summed across all years. Sampled means the total number of sites sampled including sites that were repeat-sampled.

	Site Numbers		Location Relative to Footprint			Resampled PLVA sites from		
Year	Target	Sampled	Below	Within	Above	2014	2015	2016
2014	51	58	4	34	20	-	-	-
2015	30	32	3	17	12	2	-	-
2016	30	37	4	17	16	2	3	-
2017	30	30	6	1	23	2	3	5
Sampled	-	157	17	69	71	-	-	-
Unique	-	141	17	66	58	-	-	-

FINAL REPORT FOR WORK GROUP DISTRIBUTION

In 2014, we had exceeded our planned 51-site target with 58 sites surveyed (**Table 1**). Four of the 58 sites were located below the inundation footprint of the potential dam/reservoir, 34 sites were located within the footprint, and 20 sites were located upstream of the footprint (**Appendix Figure 1**). In 2015, we had exceeded our planned 30-site target with 32 sites surveyed, including the two sites sampled in 2014 where Van Dyke's salamander had been found (**Table 1**). Three of the 32 sites were located below the inundation footprint of the potential dam/reservoir, 17 sites were located within the footprint, and 12 sites were located upstream of the footprint (**Appendix Figure 1**). The resurveyed Van Dyke's salamander sites included one within the footprint of the potential dam/reservoir and one upstream of the footprint. In 2016, we had exceeded our planned 30-site target with 37 sites surveyed, including the five sites where Van Dyke's salamander had been previously found (**Table 1**). Four of the 37 sites were located below the inundation footprint of the potential dam/reservoir, 17 sites were located within the footprint, and 16 sites were located above the footprint (**Appendix Figure 1**).

Over the four years to date (2014-2017), we exceeded our planned 132-site target with 141 unique sites surveyed (**Table 1**). Seventeen unique sites were located below the inundation footprint of the potential dam/reservoir, 66 unique sites were located within the footprint, and 58 unique sites were located upstream of the footprint (Appendix **Figure 1)**.

In 2017, we recorded observations of 586 individuals of up to 10 species of amphibians at the 30 sites sampled. We are currently completing the tally and analysis of all species found in 2017, and their associated maps, which will be available in the final product report on 30 September 2017.

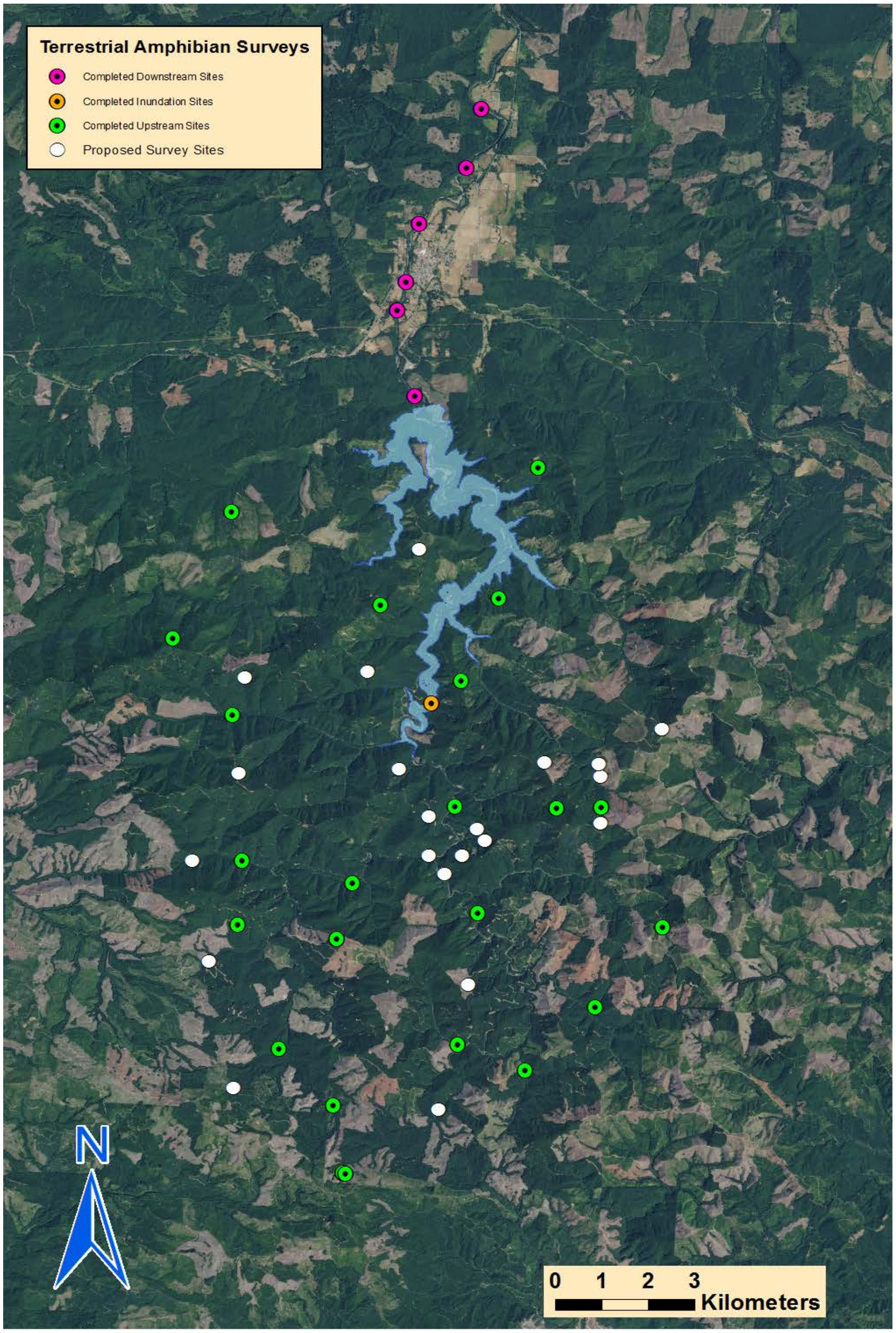
In 2014, we recorded observations of 337 individuals of up to 12 species of amphibians at the 58 sites sampled (**Appendix Table 2, Appendix Figures 2a, 2b and 2c**). We found at least one species of amphibian at 51 of the 58 sites. The four species of terrestrial amphibians recorded represent 72.7% of observations; the 8 non-terrestrial species we recorded represented 27.3% of observations.

In 2015, we recorded observations of 354 individuals of at least 10 species of amphibians at the 32 sites sampled (**Appendix Table 3, Appendix Figures 3a, 3b and 3c**). We found at least one species of amphibian at all 32 sites. The four species of terrestrial amphibians (all salamanders) recorded represent 81.9% of observations; the 8 non-terrestrial species we recorded represented 18.1% of observations.

In 2016, we recorded observations of 545 individuals of 12 species of amphibians at the 37 sites sampled (**Appendix Table 4, Figures 2a, 2b and 2c**). We found at least one species of amphibian at all 37 sites. The four species of terrestrial amphibians (all salamanders) recorded represent 69.5% of observations; the 8 non-terrestrial amphibian species we recorded represented 30.5% of observations.

Over the three years to date (2014-2016), we recorded observations of 1,236 individuals representing at least 12 species of amphibians at the 120 unique sites surveyed. We found at least one species of amphibian at every site. The four species of terrestrial amphibians (all salamanders) recorded represent 74.7% of all observations; the 8 non-terrestrial species we recorded represented 25.3% of observations.

Figure 1. Distribution for Sites for Stream-Associated Amphibians Surveys in 2017. Proposed survey sites include both sites not selected and sites rejected for the reasons specified in the text.



FINAL REPORT FOR WORK GROUP DISTRIBUTION

In 2017, western red-backed salamanders (*Plethodon vehiculum*) were the most frequently encountered terrestrial salamander species. The remainder of this paragraph will be added in the final report.

In 2014, western red-backed salamanders had also been the most frequently encountered terrestrial salamander species, representing 78.0% of all observations and recorded at 72.5% of sites (Appendix Table 1). The second most frequently encountered was Ensatina, representing 24.1% of sites, followed by Dunn's salamander, representing 9.8% of observations and recorded at 17.2% of sites. Van Dyke's salamander was the least frequently recorded species, recorded at 3.4% of sites and representing 4.9% of observations. The four terrestrial amphibians also differed in the mean number of individuals recorded per site sampled. For sites at which they were found, Van Dyke's salamanders had the highest mean number of individuals per site (6.0 individuals/site), followed by Western red-back salamanders (5.2 individuals/site), Dunn's salamanders (2.4 individuals/site), and Ensatina (1.3 individuals/site).

In 2015, western red-backed salamanders had also been the most frequently encountered terrestrial salamander species, representing 63.1% of all observations and recorded at 81.3% of sites (Appendix Table 2). The second most frequently encountered was Dunn's salamander, representing 23.4% of observations and 46.9% of sites. Ensatina and Van Dyke's salamander were the two least frequently recorded species, being found, respectively, at 18.8% and 15.6% of sites and representing 3.1% and 10.3% of observations. For sites at which they were found, the four terrestrial amphibians also differed in the mean number of individuals recorded per site sampled. Western red-back salamanders had the highest mean number of individuals per site (7.0 individuals/site), followed by Van Dyke's salamanders (6.0 individuals/site), Dunn's salamanders (4.5 individuals/site), and Ensatina (1.5 individuals/site).

In 2016, western red-backed salamanders (*Plethodon vehiculum*) had also been the most frequently encountered terrestrial salamander species, representing 61.5% of all observations and recorded at 89.2% of sites. The second most frequently encountered was Dunn's salamander, representing 22.2% of observations and recorded at 48.6% of sites. Van Dyke's salamander and Ensatina (*Ensatina eschscholztii*) were the two least frequently recorded species, being found, respectively, at 24.3% and 27.0% of sites and representing 11.6% and 4.7% of observations. Van Dyke's and western red-backed salamanders were the only two terrestrial amphibian species recorded at more sites and had more animals above the footprint of the proposed dam and reservoir than anywhere else. The four terrestrial amphibians also differed in the mean number of individuals recorded per site sampled. For sites at which they were found, western red-back salamanders had the highest mean number of individuals per site (7.1 individuals/site), followed by Van Dyke's salamanders (4.9 individuals/site), Dunn's salamanders (4.7 individuals/site), and Ensatina (1.8 individuals/site).

Overall (2014-2016), western red-backed salamanders (*Plethodon vehiculum*) were the most frequently encountered of terrestrial salamanders observed, representing 49.1% of all observations and recorded at 77.5% of sites. The second most frequently encountered was Dunn's salamander, representing 14.2% of observations and recorded at 34.2% of sites. Van

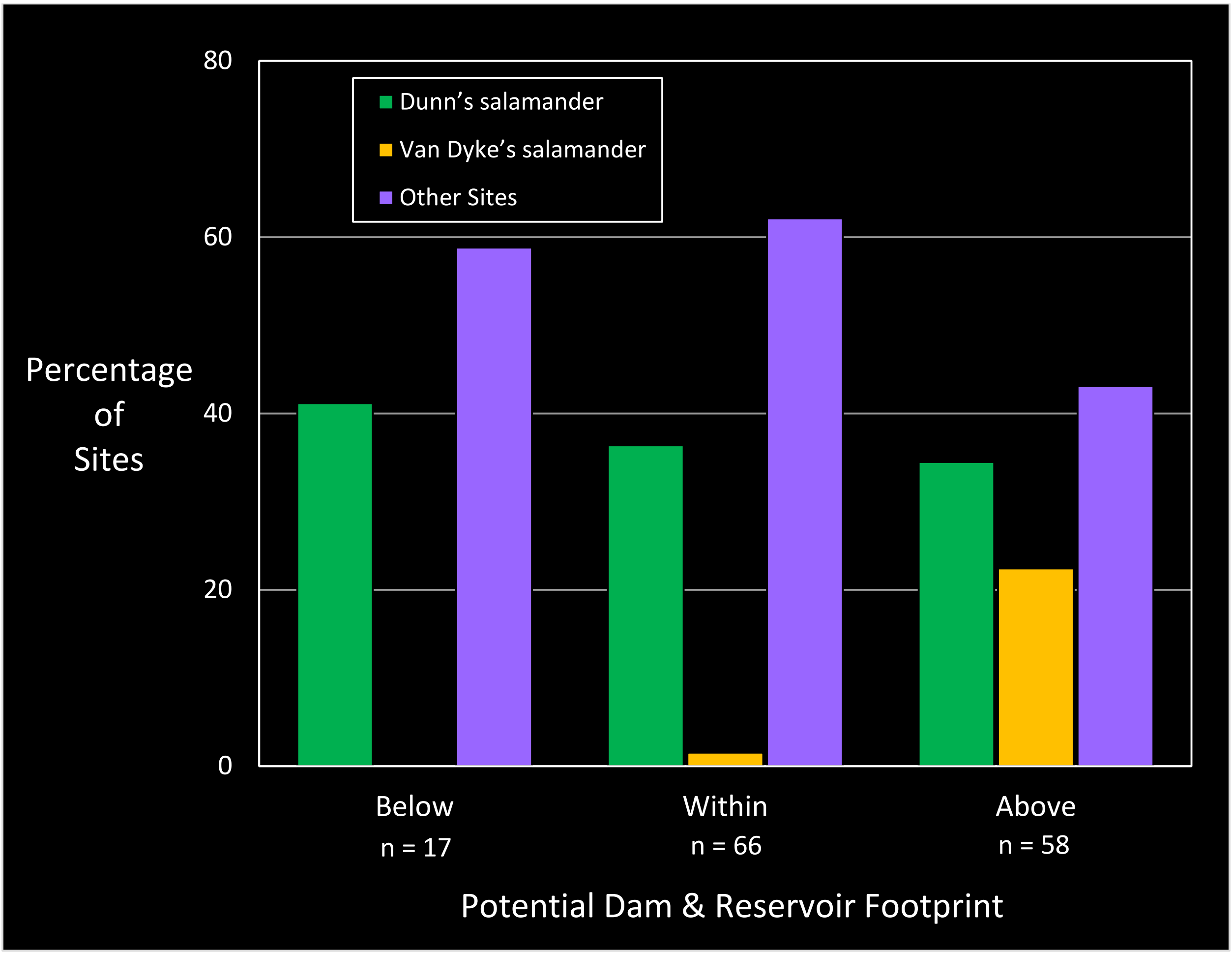
Dyke's salamander and Ensatina were the two least frequently recorded species, being found, respectively, at 7.5% and 25.0% of sites, and representing, respectively, 7.0% and 3.6% of observations. Van Dyke's had more animals above the footprint of the dam than anywhere else. The four terrestrial amphibians also differed in the mean number of individuals recorded per site sampled. Western red-back salamanders had the highest mean (6.5 individuals/site), followed by Van Dyke's salamanders (5.6 individuals/site), Dunn's salamanders (3.9 individuals/site), and Ensatina (1.5 individuals/site). The preceding balance of this paragraph will be updated in the final report. Van Dyke's salamanders were found at all nine sites where they were recorded in 2014, 2015, and 2016, and at five new sites above the potential dam/reservoir footprint.

Dunn's and Van Dyke's salamanders are also differentially distributed relative to the location of the proposed dam/reservoir footprint and elevation. Based on location relative to the footprint across all years (2014-2017), we found no Van Dyke's salamanders below the footprint and at only one site within the footprint (2% of 66 unique sites sampled within the footprint); all remaining Van Dyke's salamander locations (n = 13) were above the footprint and represented 22% of the 58 unique sites sampled above the footprint (**Figure 2**). In contrast, Dunn's salamander was found with greater frequency below, within and above the footprint with the percent of sites where the species was detected ranging from 41% of 17 unique sites sampled below the footprint to 36% of 66 unique sites within the footprint to 34% of 58 unique sites above the footprint. However, location partitioning relative to the proposed dam/reservoir footprint conceals a prominent pattern relative to elevation. Partitioning into 750-ft elevation blocks reveals that Dunn's salamander is roughly equally distributed in distribution, measured as the proportion of sites where detected, in the two lowest elevations blocks, but drops off markedly in the highest elevation block (**Figure 3**). In contrast, Van Dyke's salamander was not detected in the lowest elevation block, was rare in the mid-elevation block (found at one site), and all remaining sites were it was found were in the highest elevation block. However, in contrast to Dunn's salamander, the frequency with which Van Dyke's salamander was detected across the landscape was consistently lower.

Discussion: With few exceptions, patterns we observed in 2017 are similar to those observed during surveys in years 2014, 2015, and 2016. The remaining balance of this paragraph will be updated in the final report. As expected, since the surveys were designed to detect terrestrial salamanders, most amphibians detected were terrestrial salamanders. In particular, terrestrial salamander observations (n = 914 across 2014-2016) represented 69.5% to 81.9% ($\bar{x}$ = 74.7%) of amphibians found across each of the three years. However, a substantial number (n = 322) of amphibians representing 11 additional species were recorded incidentally in these surveys. This richness underscores the high amphibian species richness of the Chehalis Basin, which is the highest in Washington State and equaled only by a few areas in the South Cascades (Dvornich et al. 1997). This richness occurs in a landscape that is entirely timber-managed.

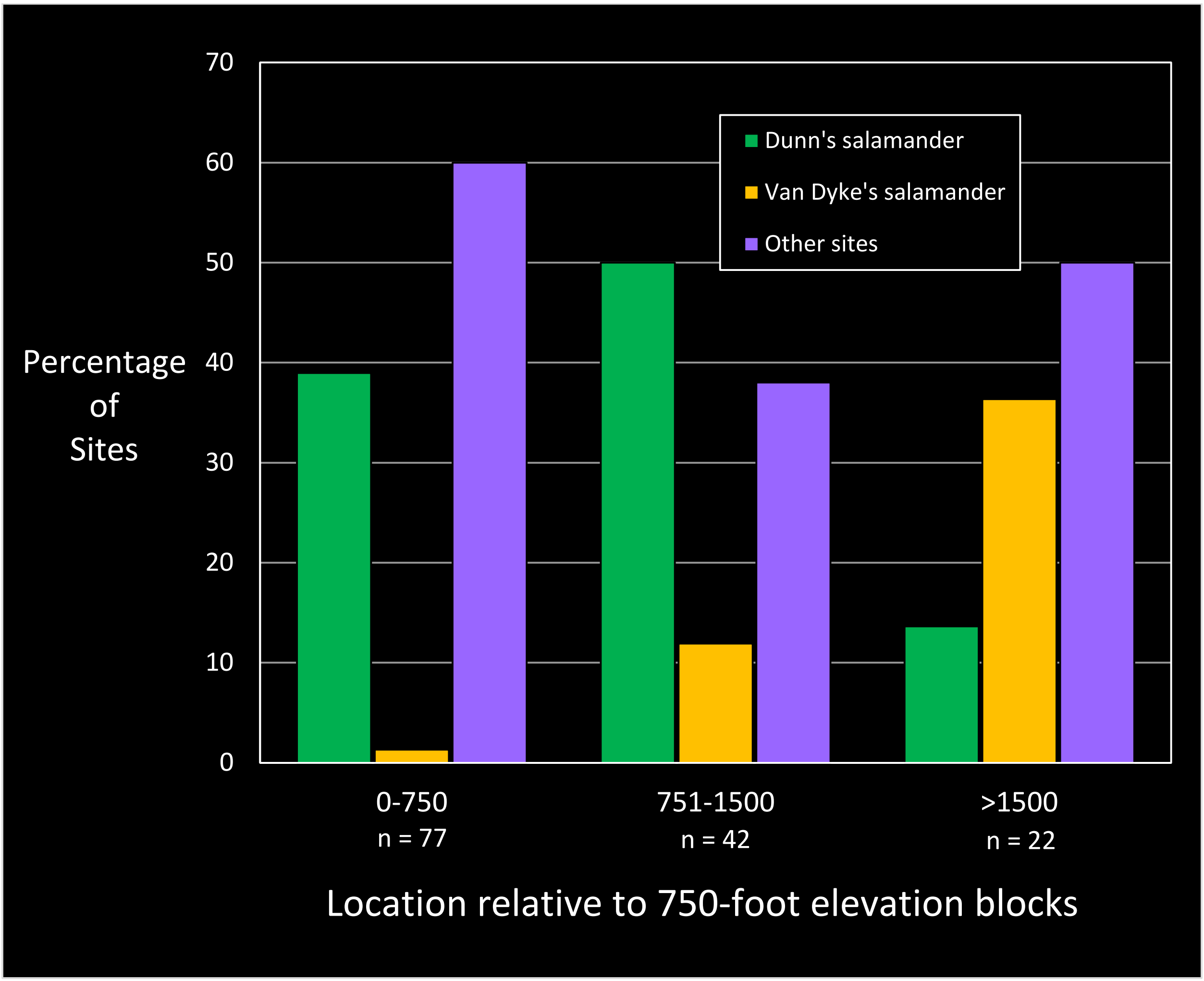
Perhaps the most striking difference in 2016 data is the higher numbers of amphibians per sites encountered when contrasted to 2014 and 2015. In particular, we found 14.7 amphibians per sample site in 2016, this contrasts to 5.8 amphibians/site in 2014 and 11.0 amphibians per site in 2015. This pattern likely reflects greater terrestrial salamander surface activity under wetter conditions; the October 2015-March 2016 interval was regionally the wettest in the historical record.

Figure 2. Distribution of Dunn's and Van Dyke's salamanders relative to the footprint of the proposed dam and reservoir. Number of unique sites sampled in each location category across all years combined (2014-2017) are indicated below category labels. Other sites were sites where neither Dunn's nor Van Dyke's salamanders were found.



Western red-backed salamander was the most frequently recorded terrestrial amphibian; this agrees with previous work on Western red-backed salamanders, which require relatively mesic terrestrial habitats, are typically the most frequently recorded terrestrial salamander in the generally more mesic Willapa Hills (M. Hayes, unpublished data) as well as generally in Coast Ranges habitats in Washington (Raphael et al. 2002).

Figure 3. Distribution of Dunn's and Van Dyke's salamanders relative to elevation. Number of unique sites sampled in each elevation category across all years combined are indicated below category labels. Other sites were sites where neither Dunn's nor Van Dyke's salamanders were found.



Ensatina, a relatively drier habitat-adapted terrestrial salamander species, was much less frequent than the Western red-backed salamander in this mesic Coast Range habitat, a pattern also recorded elsewhere (Raphael et al. 2002). Ensatina tends to be more frequent in more interior, forested Oregon and Washington (Bury et al. 1991). Further, our surveys were riparian-focused to enable detecting Dunn's and Van Dyke's salamanders, they would be expected to be less frequent in the riparian margin than in the drier adjacent uplands. We recorded Ensatina at a slightly greater proportion of sites in 2014 (24.1%) & 2016 (27.0%) in contrast to 2015 (18.8%). Opportunistic draw within in our stratified random selection of sites may be the basis as analysis among those proportions reveals them to not differ significantly.

Dunn's salamander was more frequently recorded than Ensatina, which likely simply reflects the riparian-focused nature of our surveys. Dunn's salamander, a terrestrial salamander with greater moisture requirements than Ensatina, is a more stream-associated terrestrial species and the terrestrial amphibian surveys were stream margin-focused. We did not survey the less mesic uplands away from the stream, where more Ensatina might be expected. Dunn's salamander was relatively frequently recorded within the footprint of the proposed dam and reservoir (Figure 3), but appears to be less frequent at higher elevations (Figure 4).

Van Dyke's salamander was infrequently recorded. Van Dyke's salamander, also strongly stream-associated species, is the least frequently recorded terrestrial salamander in several Coast Range habitats and other studies in western Washington (Wilkins and Peterson 2000, Raphael et al. 2002, McIntyre 2003, Wilk et al. 2014). Only two historical records existed for Van Dyke's salamander from the upper Chehalis system prior to these surveys (WDFW WSDM database, accessed 12 February 2014). Both records originated from the studies that Weyerhaeuser conducted when they developed their Landscape Conservation Plan across the Willapa Hills landscape in the 1990s and both come from what is best described as mid-elevation in the Chehalis headwaters (around 1300 feet [400 m]). We found Van Dyke's salamander at five new sites in 2017, all of which were above the proposed footprint of the dam. Though Van Dyke's salamander has been found at few sites overall (n = 14), the distribution of sites at which it was found indicates that the species is more frequent above (n = 13) than within (n = 1) the proposed dam/reservoir footprint. However, the pattern is consistent with this species being a cool-adapted stenotherm, since the old Forest Service *Survey and Manage Species* criteria for Van Dyke's salamander recommend that surveys be conducted at air temperatures ≤15°C [59°F] (Jones 1999), and temperatures that satisfy its presumed optimal thermal regime are more frequent at the higher elevations.

The differential pattern between Dunn's and Van Dyke's salamanders indicates that in the event of construction of either an FRO or FRFA dam option, Dunn's salamander would lose significant habitat with the reservoir footprint in either option. In contrast, Van Dyke's salamander would proportionally lose much less suitable habitat than Dunn's salamander. Both the FRO and FRFA options are anticipated to eliminate riparian habitat with the structure that could currently support either Dunn's or Van Dyke's salamanders because vegetation removal in the reservoir footprint is expected under either option, and the new riparian margin conditions are not only unlikely to be suitable, but the dynamics of stage (water level), seasonal in the FRFA and irregular in the FRO, are unlikely to create riparian conditions that would promote re-establishment of these two species. Since the habitat for both these salamanders is exclusively riparian, the reservoir footprints for either dam option are likely to also isolate Dunn's and Van Dyke's salamander populations in tributaries to the Chehalis mainstem where habitat for both species is anticipated to remain. What that isolation will do to local gene flow in populations of both these species is unknown.

We should also note that in the anticipated climate change trajectory, we would expect Van Dyke's salamander to retreat upwards in elevation, where Dunn's salamander would be expected to expand upwards in elevation. However, at a certain point, Dunn's expansion upwards in elevation may be accompanied by a retreat along its lower elevation limit. Both these patterns are excellent justification for including acquisitions in the headwater portions of this system to help attenuate the climate change trajectory as part of the ASRP restoration options.

LITERATURE CITED

Bury, R.B., P.S. Corn, and K.B. Aubry. 1991. Regional patterns of terrestrial amphibian communities in Oregon and Washington. Pp. 340-350. In: L.F. Ruggiero, K.B. Aubry, A.B. Carey, and M.H. Huff (technical coordinators), *Wildlife and Vegetation of Unmanaged Douglas-fir Forests*. USDA, Forest Service, Pacific Northwest Research Station, General Technical Report PNW-GTR-285. [May]

Dvornich, K.M., K.R. McAllister, and K.B. Aubry. 1997. Amphibians and reptiles of Washington State: Location data and predicted distributions. In Volume 2 of *Washington State Gap Analysis - Final Report*, edited by K.M. Cassidy et al., Washington Cooperative Fish and Wildlife Research Unit, University of Washington, Seattle.

Jones, L.L.C. 1999. Chapter VI: Survey protocol for the Van Dyke's Salamander (*Plethodon vandykei*), pp. 201-252. In: Olson, D.H. (editor and subgroup lead), *Survey Protocols for Amphibians under the Survey and Manage Provision of the Northwest Forest Plan, Version 3.0*.

McIntyre, A.P. 2003. *Ecology of populations of Van Dyke's salamanders in the Cascade Range of Washington State*. Masters Thesis, Department of Fisheries and Wildlife, Oregon State University, Corvallis. 128 pp.

Ovaska, K. 1988. Spacing and movements of the salamander *Plethodon vehiculum*. *Herpetologica* 44(4):377-386.

Raphael, M.G., P.A. Bisson, L.L.C. Jones, and A.D. Foster. 2002. Effects of streamside forest management on the composition and abundance of stream and riparian fauna of the Olympic Peninsula. Pp. 27-40. In: A.C. Johnson, R.W. Haynes, and R.A. Monserud (editors), *Proceedings from the Wood Compatibility Initiative Workshop* (3). USDA, Forest Service, Pacific Northwest Research Station, PNW-GTR-563. [November]

Staub, N.L., C.W. Brown, and D.B. Wake. 1995. Patterns of growth and movements in a population of *Ensatina eschscholtzii platensis* (Caudata: Plethodontidae) in the Sierra Nevada, California. *Journal of Herpetology* 29(4):593-599.

Wilk, R.J., D. Ricklefs, and M.G. Raphael. 2014. Abundance of Western red-backed salamanders (*Plethodon vehiculum*) in the Washington Coast Range after headwater stream-buffer manipulation. *Northwestern Naturalist* 95(2):92-102.

Wilkins, R.N., and N.P. Peterson. 2000. Factors related to amphibian occurrence and abundance in headwater streams draining second-growth Douglas-fir forests in southwestern Washington. *Forest Ecology and Management* 139(1-3):79-91.

Appendix Table 1. Amphibian species and numbers of observations during terrestrial amphibian surveys, February-July 2014. Subtotals or totals for sites may be less than summed site sums for species across habitat categories because one or more species may have occurred at the same site.

Species		Numbers of *Sites* and *Individuals* (*Ind*) observed							
Standard English Name	Scientific Name	Below footprint		In footprint		Above footprint		**Totals**	
		Sites	*Ind*	*Sites*	*Ind*	*Sites*	*Ind*	*Sites*	*Ind*
Terrestrial Amphibians									
Dunn's salamander	*Plethodon dunni*	0	0	7	16	3	8	**10**	**24**
Ensatina	*Ensatina eschscholtzii*	1	1	5	6	8	11	**14**	**18**
Van Dyke's salamander	*Plethodon vandykei*	0	0	1	5	1	7	**2**	**12**
Western red-backed salamander	*Plethodon vehiculum*	3	7	18	93	16	91	**37**	**191**
	Subtotals	**3**	**8**	**20**	**120**	**17**	**117**	**40**	**245**
Stillwater-breeding Amphibians									
Pacific treefrog	*Pseudacris regilla*	0	0	6	11	0	0	**6**	**11**
Northern red-legged frog	*Rana aurora*	1	1	1	1	1	1	**3**	**3**
Roughskin newt	*Taricha granulosa*	0	0	2	2	1	2	**3**	**4**
Western toad	*Anaxyrus boreas*	1	1	6	10	2	2	**9**	**13**
	Subtotals	**3**	**2**	**20**	**24**	**4**	**5**	**27**	**31**
Stream-breeding Amphibians									
Giant salamanders	*Dicamptodon sp.*	0	0	0	0	4	4	**4**	**4**
Coastal tailed frog	*Ascaphus truei*	0	0	5	6	4	6	**9**	**12**
Columbia torrent salamander	*Rhyacotriton kezeri*	0	0	6	34	7	11	**13**	**45**
	Subtotals	**0**	**0**	**11**	**40**	**9**	**21**	**20**	**61**
	Overall Totals	**6**	**10**	**23**	**184**	**22**	**143**	**48**	**337**

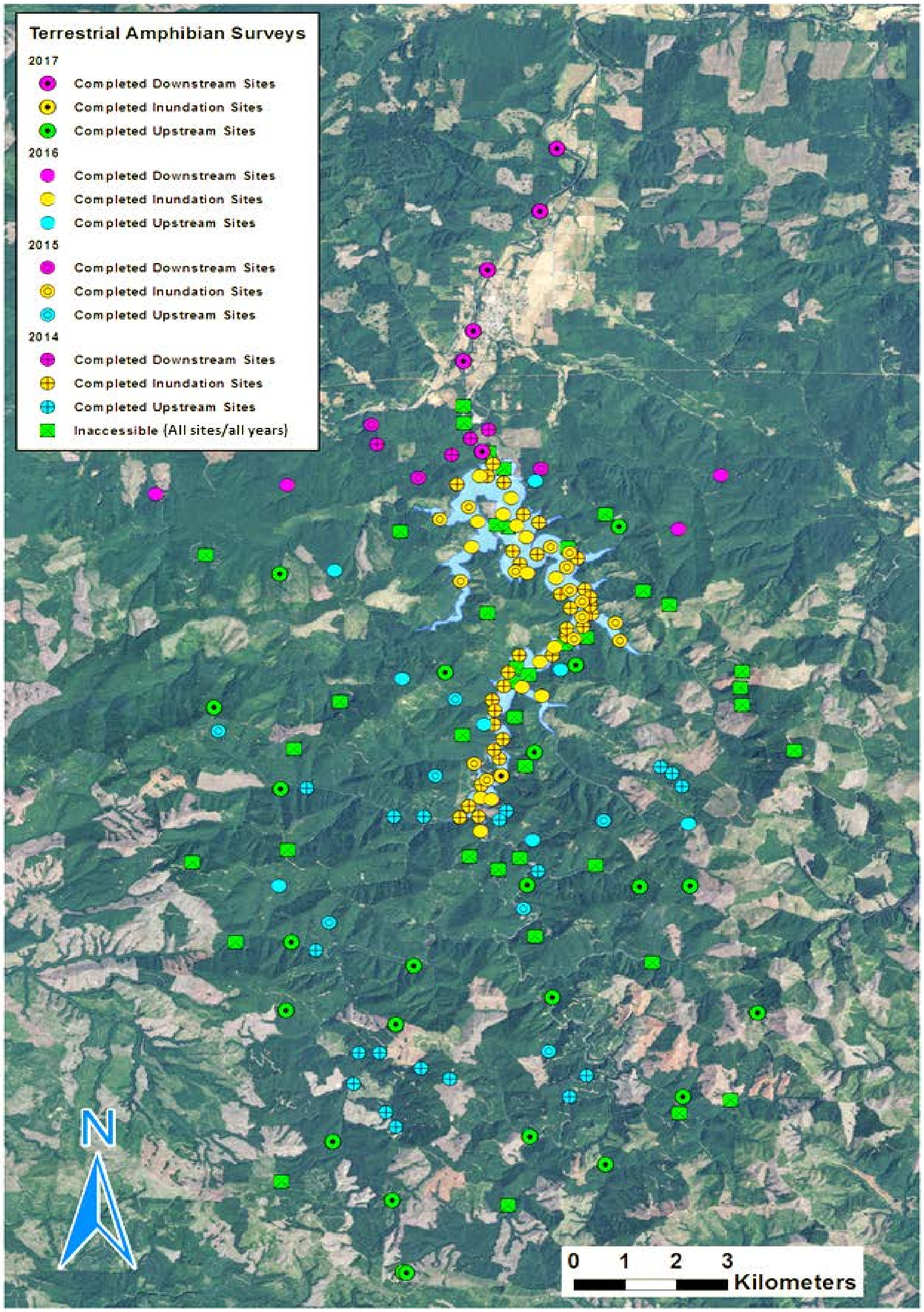
Appendix Table 2. Amphibian species and numbers of observations during terrestrial amphibian surveys, March-April 2015. Subtotals or totals for sites may be less than summed site sums for species across habitat categories because one or more species may have occurred at the same site.

Species		Numbers of *Sites* and *Individuals* (*Ind*) observed							
Standard English Name	Scientific Name	Below footprint		In footprint		Above footprint		**Totals**	
		Sites	*Ind*	*Sites*	*Ind*	*Sites*	*Ind*	*Sites*	*Ind*
Terrestrial Amphibians									
Dunn's salamander	*Plethodon dunni*	2	3	9	36	4	29	**15**	**68**
Ensatina	*Ensatina eschscholtzii*	1	2	3	4	2	3	**6**	**9**
Van Dyke's salamander	*Plethodon vandykei*	0	0	1	3	4	27	**5**	**30**
Western red-backed salamander	*Plethodon vehiculum*	3	5	13	73	10	105	**26**	**183**
	Subtotals	**3**	**10**	**15**	**116**	**10**	**164**	**27**	**290**
Stillwater-breeding Amphibians									
Pacific treefrog	*Pseudacris regilla*	1	3	2	5	1	2	**4**	**10**
Northern red-legged frog	*Rana aurora*	0	0	0	0	0	0	**0**	**0**
Roughskin newt	*Taricha granulosa*	1	6	1	1	0	0	**2**	**7**
Western toad	*Anaxyrus boreas*	0	0	7	7	1	1	**8**	**8**
	Subtotals	**2**	**9**	**8**	**13**	**2**	**3**	**12**	**25**
Stream-breeding Amphibians									
Coastal giant salamanders	*Dicamptodon tenebrosus*	0	0	0	0	1	2	**1**	**2**
Coastal tailed frog	*Ascaphus truei*	0	0	1	2	4	5	**5**	**7**
Columbia torrent salamander	*Rhyacotriton kezeri*	1	2	5	19	4	9	**10**	**30**
	Subtotals	**1**	**2**	**5**	**21**	**5**	**16**	**11**	**39**
	Overall Totals	**4**	**21**	**18**	**150**	**10**	**183**	**32**	**354**

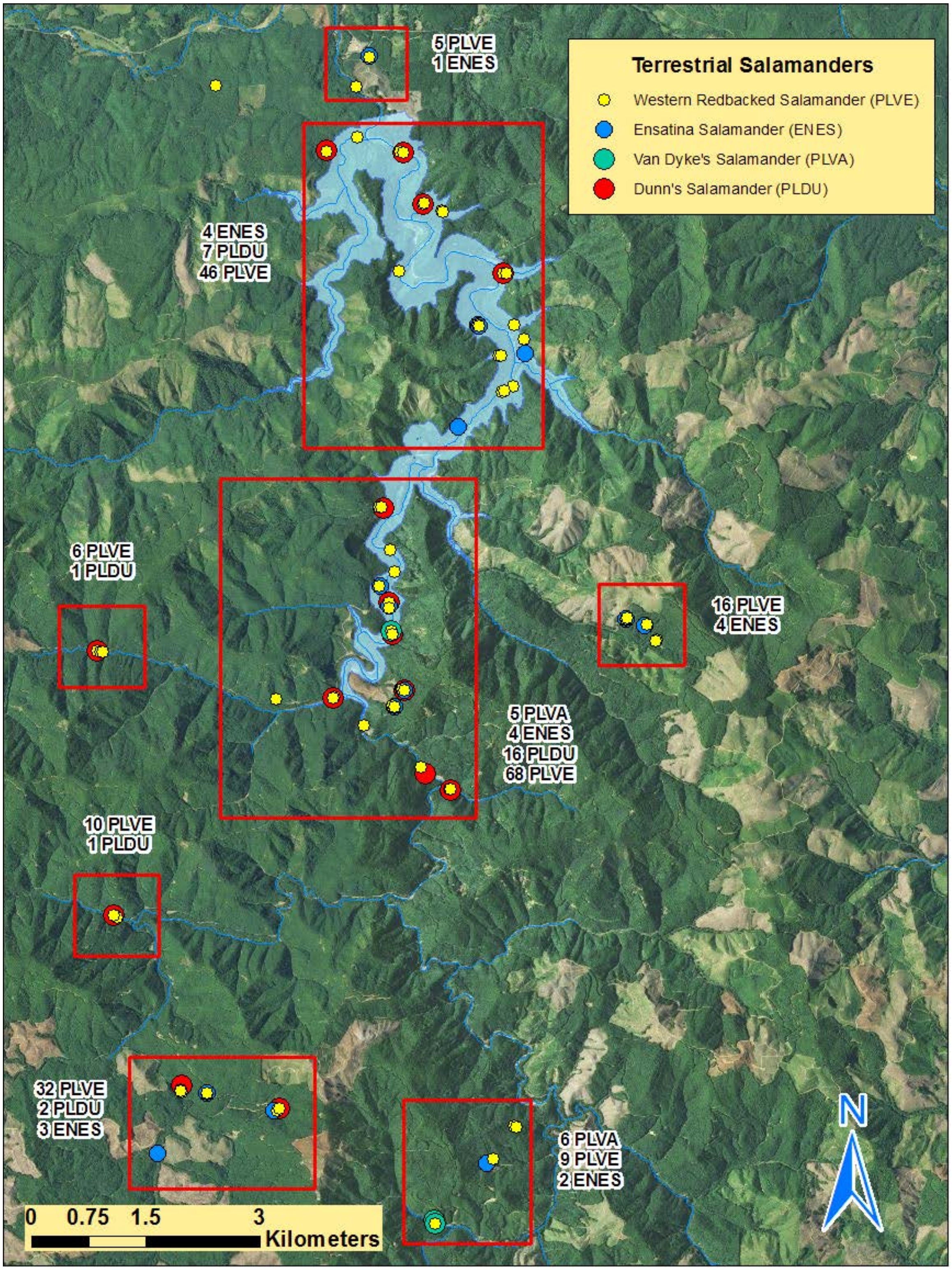
Appendix Table 3. Amphibian species and numbers of observations during terrestrial amphibian surveys, March-May 2016. Subtotals or totals for sites may be less than summed site sums for species across habitat categories because one or more species may have occurred at the same site. The overall number of sites includes two sites with incidental observations.

Species		Numbers of *Sites* and *Individuals* (*Ind*) observed							
Standard English Name	Scientific Name	Below footprint		In footprint		Above footprint		**Totals**	
		Sites	*Ind*	*Sites*	*Ind*	*Sites*	*Ind*	*Sites*	*Ind*
Terrestrial Amphibians									
Dunn's salamander	*Plethodon dunni*	1	1	10	44	7	39	**18**	**84**
Ensatina	*Ensatina eschscholtzii*	3	5	4	10	3	3	**10**	**18**
Van Dyke's salamander	*Plethodon vandykei*	0	0	1	2	8	42	**9**	**44**
Western red-backed salamander	*Plethodon vehiculum*	4	13	15	95	14	125	**33**	**233**
Subtotals		**4**	**19**	**15**	**151**	**16**	**209**	**35**	**379**
Stillwater-breeding Amphibians									
Pacific treefrog	*Pseudacris regilla*	0	0	5	7	1	1	**6**	**8**
Northern red-legged frog	*Rana aurora*	1	1	1	1	3	3	**5**	**5**
Northwestern salamander	*Ambystoma gracile*	2	4	1	1	1	1	**4**	**6**
Roughskin newt	*Taricha granulosa*	1	1	2	2	3	5	**6**	**8**
Western toad	*Anaxyrus boreas*	0	0	8	21	3	3	**11**	**24**
Subtotals		**3**	**6**	**10**	**32**	**9**	**13**	**22**	**51**
Stream-breeding Amphibians									
Giant salamanders	*Dicamptodon tenebrosus*	1	1	0	0	5	13	**6**	**14**
Coastal tailed frog	*Ascaphus truei*	1	1	1	1	7	16	**9**	**18**
Columbia torrent salamander	*Rhyacotriton kezeri*	1	3	6	30	11	50	**18**	**83**
Subtotals		**3**	**5**	**7**	**31**	**13**	**79**	**23**	**115**
Overall Totals		**10**	**30**	**17**	**214**	**16**	**301**	**37**	**545**

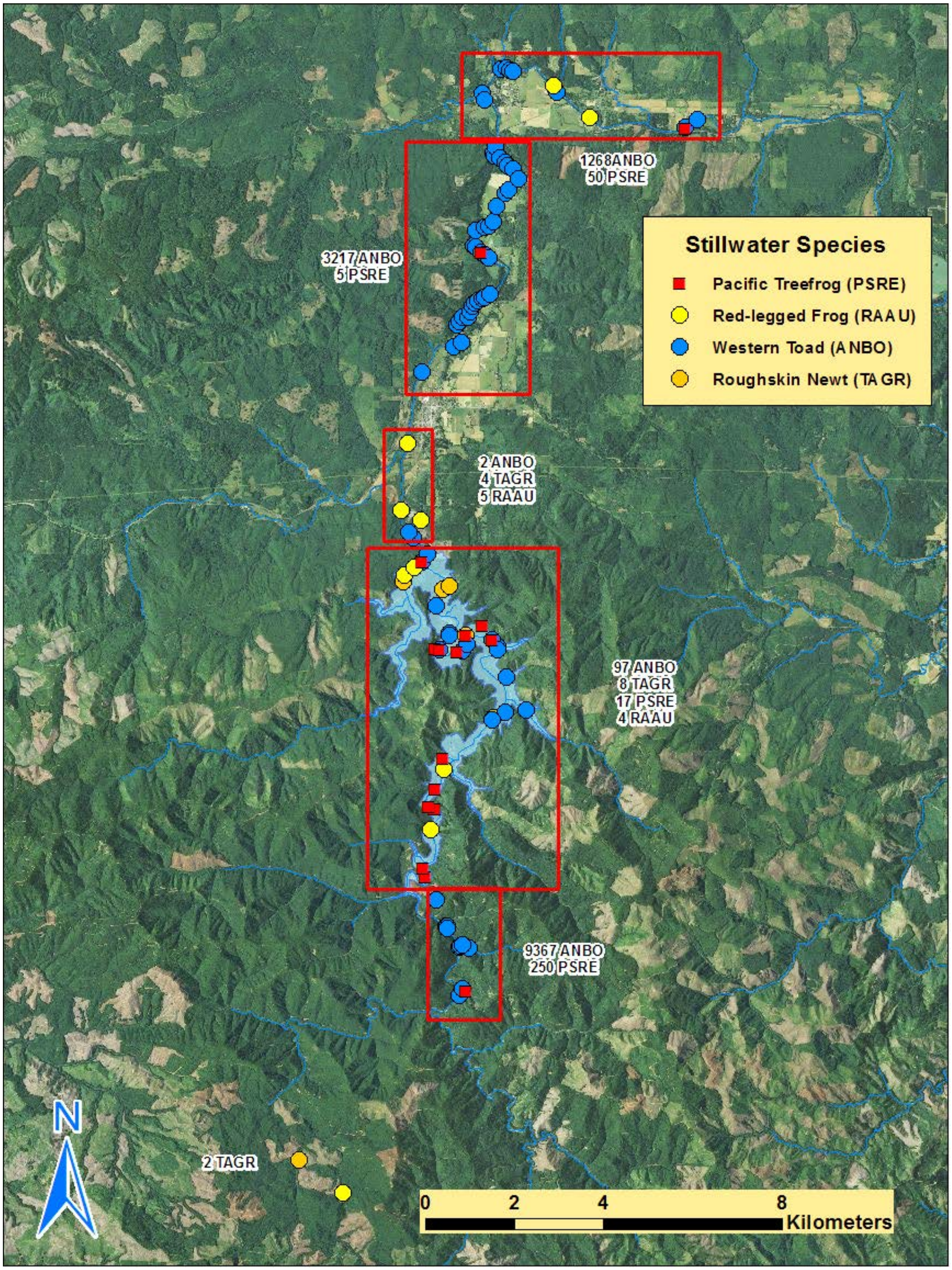
Appendix Figure 1. Location of sampled stream-associated amphibian survey sites by year. Color coding indicates whether sites were downstream of the proposed dam and reservoir footprint (downstream), within the proposed dam and reservoir footprint (inundation) or above the proposed dam and reservoir footprint (upstream). Inaccessible sites shown in green squares.



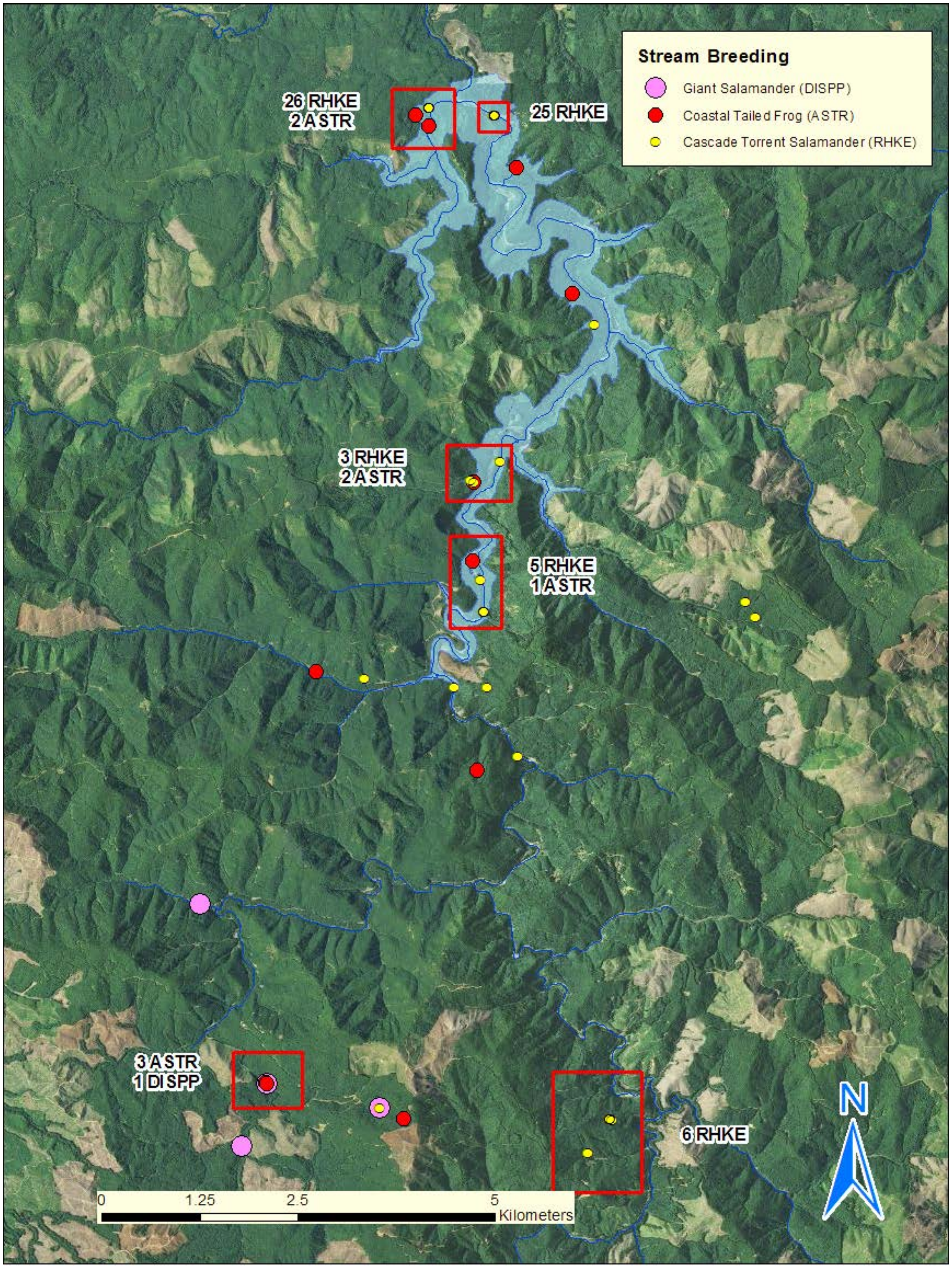
Appendix Figure 2a. Distribution of terrestrial amphibians, including stream-associated taxa, encountered in 2014. Numbers of specific taxa are summarized adjacent to either individual points or boxes encompassing groups of individual points.



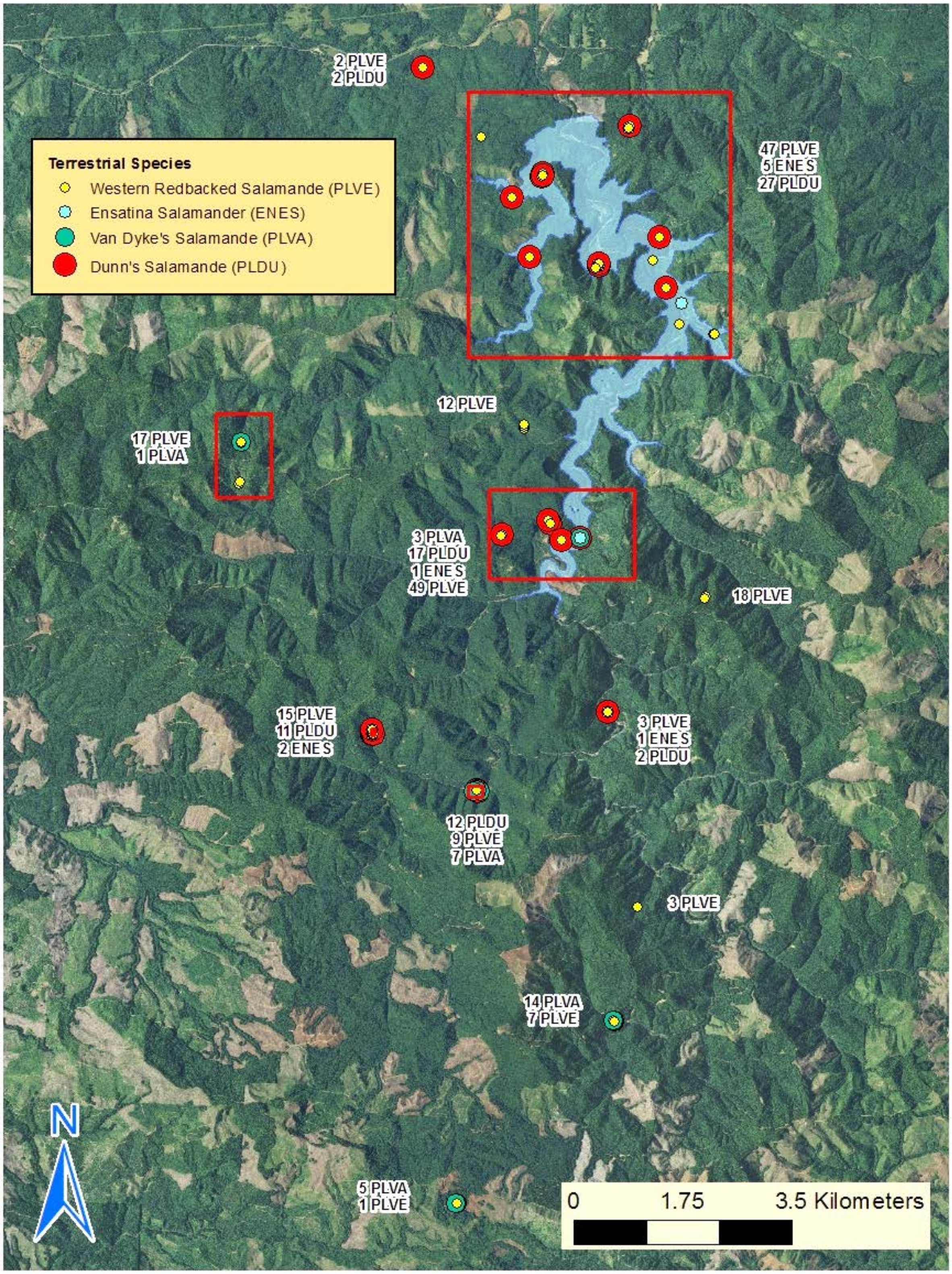
Appendix Figure 2b. Distribution of stillwater-breeding amphibians incidentally recorded during stream-associated amphibian surveys in 2014. Numbers of specific taxa are summarized next to individual points.



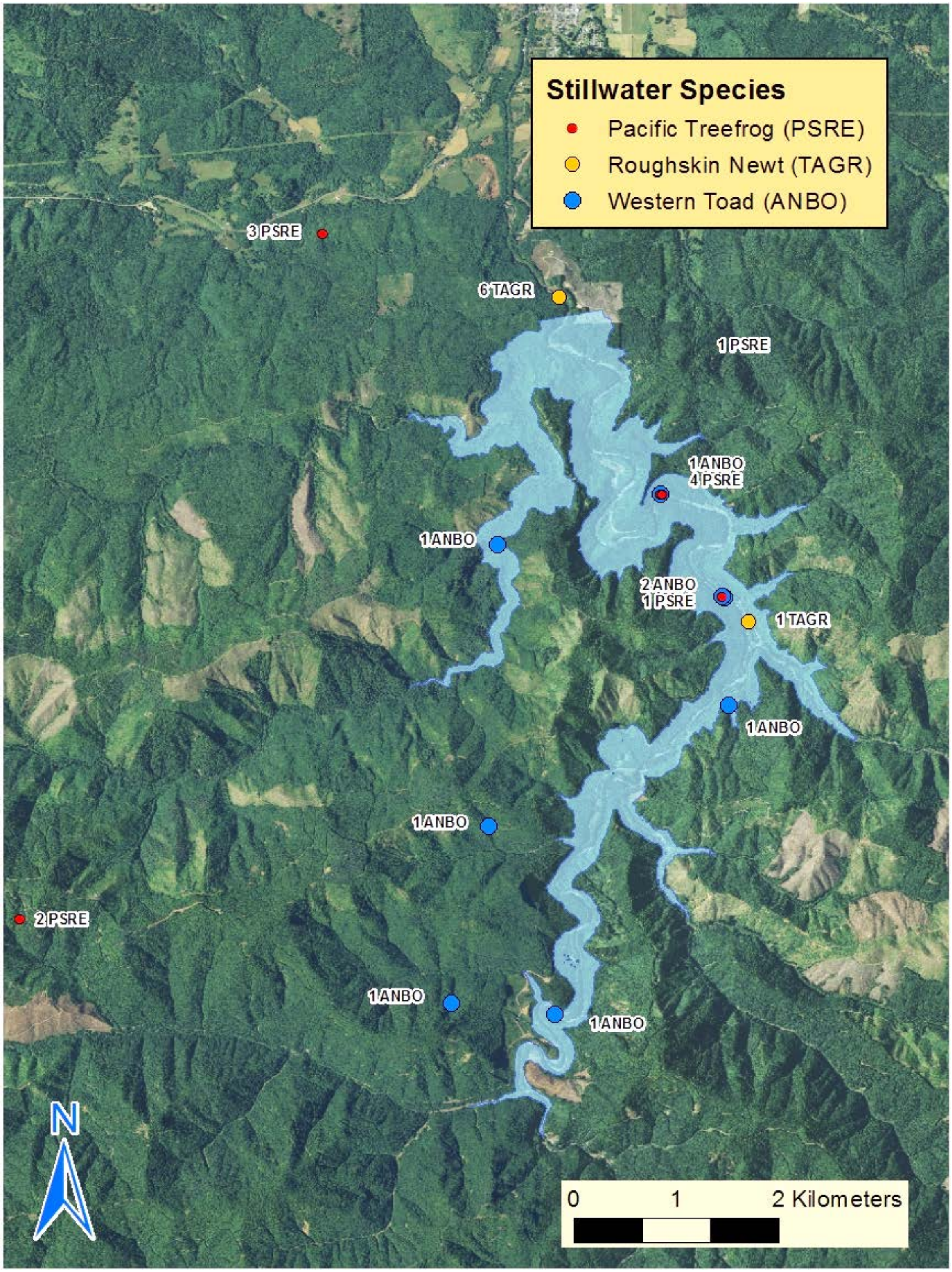
Appendix Figure 2c. Distribution of stream-breeding amphibians incidentally recorded during stream-associated amphibian surveys in 2014. Numbers of specific taxa are summarized adjacent to either individual points or boxes encompassing groups of individual points.



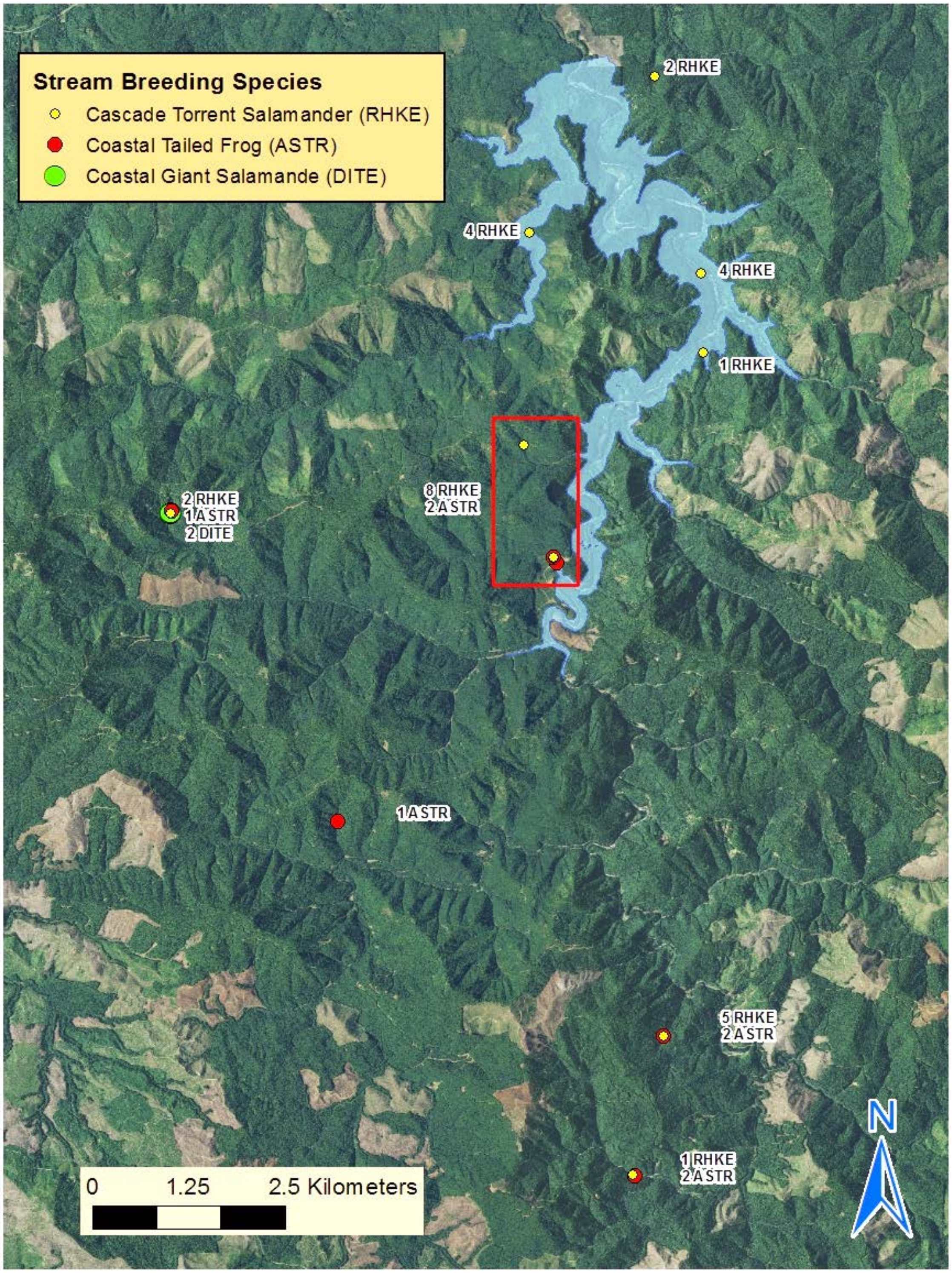
Appendix Figure 3a. Distribution of terrestrial amphibians, including stream-associated taxa, encountered in 2015. Numbers of specific taxa are summarized adjacent to either individual points or boxes encompassing groups of individual points.



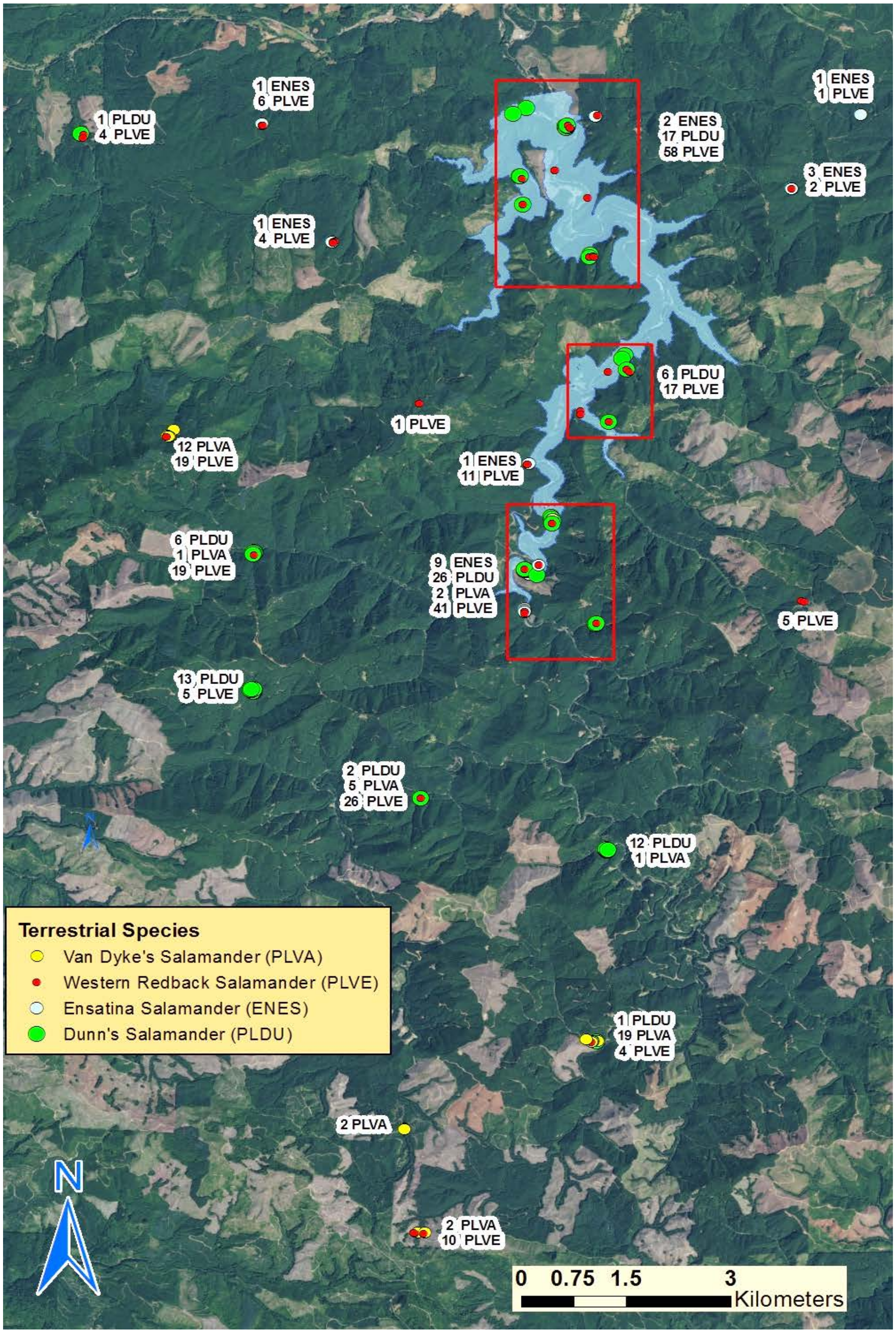
Appendix Figure 3b. Distribution of stillwater-breeding amphibians incidentally recorded during stream-associated amphibian surveys in 2015. Numbers of specific taxa are summarized next to individual points.



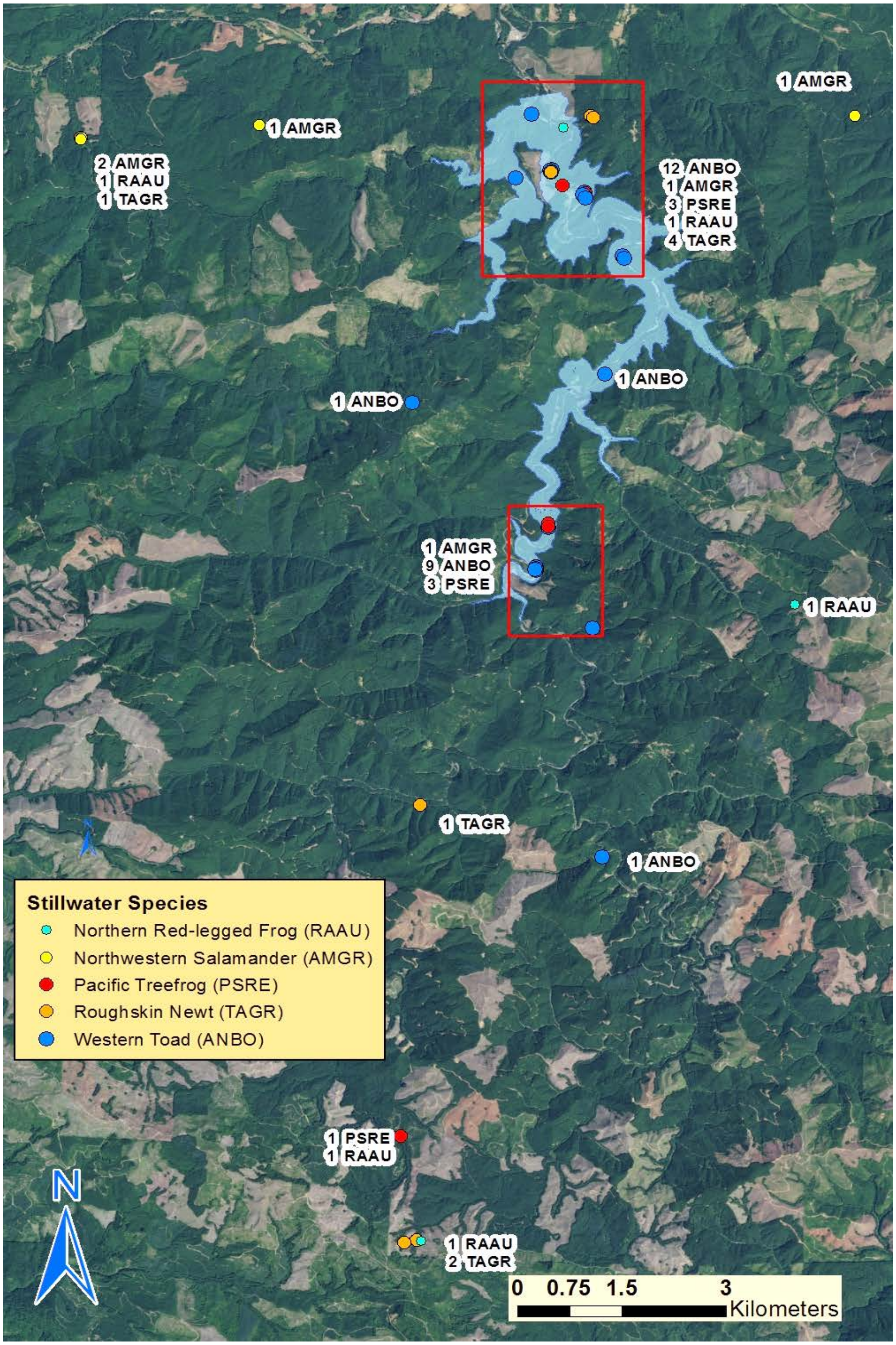
Appendix Figure 3c. Distribution of stream-breeding amphibians incidentally recorded during stream-associated amphibian surveys in 2015. Numbers of specific taxa are summarized adjacent to either individual points or boxes encompassing groups of individual points.



Appendix Figure 4a. Distribution of terrestrial amphibians, including stream-associated taxa, encountered in 2016. Numbers of specific taxa are summarized adjacent to either individual points or boxes encompassing groups of individual points.



Appendix Figure 4b. Distribution of stillwater-breeding amphibians incidentally recorded during stream-associated amphibian surveys in 2016. Numbers of specific taxa are summarized next to individual points or boxes encompassing groups of individual points.



Appendix Figure 4c. Distribution of stream-breeding amphibians incidentally recorded during stream-associated amphibian surveys in 2016. Numbers of specific taxa are summarized adjacent to either individual points or boxes encompassing groups of individual points.