CHEHALIS BASIN STRATEGY

WESTERN TOADS

Study Goals and Objectives

Western Toads are a species of greatest conservation need (SGCN) in Washington and an ASRP indicator species. Chehalis Basin Toad surveys support ASRP goals by identifying the presence, distribution, and habitat needs as well as long-term status and trend patterns. This work also supported Environmental Impact Statement (EIS) assessments for the proposed flood retention project. Analyses based on our basin-wide census efforts from 2014-2022 can also inform restoration efforts, including potential impacts to and prioritization for Toad breeding habitats.

In summer 2023 we transitioned from basin-wide censusing to establishing long-term survey sites to document temporal patterns of Toad breeding. This work is focused in the four watersheds that we identified from occupancy sampling (2014-2022) which had the largest concentrations of Toad breeding activity: the Upper Chehalis, Humptulips, Satsop, and Wynoochee Rivers. Annual surveys over fixed reaches within each watershed will be used to document trends in occupancy and abundance in relation to climate change, land use, and river habitat alterations.

Methods / Study Design

Western Toads in the Chehalis Basin tend to breed within the summer low flow river channel in slow flow stream margins or in offchannel pools. This behavior differs from the stillwater habitats they tend to breed in elsewhere. For our prior census and ongoing Status and Trends surveys, 2-5 technicians conduct visual encounter surveys by walking and/or kayaking both margins of streams and any additional braids or channels, stopping to record all locations with evidence of recent toad breeding activity (eggs, tadpoles, toadlets, or congregating adults). At breeding sites, a suite of biotic data including the number of masses, tadpoles, metamorphs, juveniles, or adults and presence of other co-occurring aquatic species (including fish) are recorded. Physical data for breeding sites recorded includes location, bank side and several structural features like water depth, pool width, substrate composition, water velocity, water temperature, percent canopy cover, dominant canopy species, and a description of connection to the riverine main flow channel if any.

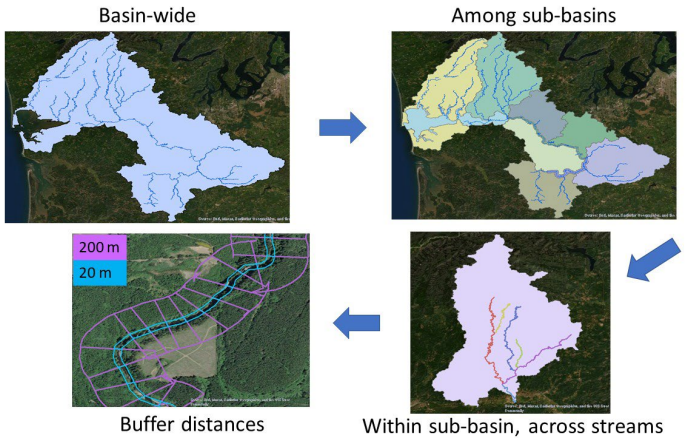

Figure 1. Conceptual model of our analytical framework for analyzing Basin-wide, sub-basin, within-basin, and local versus landscape pattern of habitat conditions for Toad breeding.

We used eight years of Basin-wide survey data to assess whether geographic regions, landcover conditions at multiple spatial/hydrological scales, and mean May in-stream temperature determine what, if any, habitat conditions are associated with Western Toad breeding (**Figure 1**). We assessed high-resolution landcover data at two different buffer scales for streams, riparian (20-m) and landscape (200 m), that represent possible habitat restoration goals for the Western Toad. Our habitat data sources included WDFW's high resolution (1-m) landcover layer and the Chehalis Basin Thermalscape data (Pierce 2017, Winkowski 2018). We produced a series of points along surveyed reaches where Toads were not detected, collected environmental data at these points, and used these in our analysis as pseudo-absences. Finally, we used generalized linear mixed effects models and an information theoretic approach to determine which habitat conditions shapes Toad breeding occupancy in the Chehalis Basin.

In 2023, we selected a subset of known Western Toad breeding sites from 2014-2022 census surveys (**Figure 2**), choosing sites that were spatially representative of all four watersheds. We centered a 400m stream reach on these sites to establish long-term survey reaches. We are now collecting additional habitat data at equally spaced transects along the reach and are censusing Toad breeding across the entire reach. In addition to standard habitat structure data during census surveys, we will also collect transect-specific data such as type of land use on each bank side, bank condition, large wood, and data on additional channels, bars, or braids present. These habitat data will quantify changes to the landscape over time that may influence Toad breeding and larval rearing.

Genetics: Using a multi-locus genome-wide probe set, we sequenced representative Toad tissue samples from each watershed in the Basin. Final analyses are pending but will highlight the degree of gene flow and genetic diversity in the Chehalis Basin.

Summary of Results

In 2022 we completed our Basin-wide census for Toad breeding surveying over 700 river miles (**Figure 2**). Toad breeding was prevalent in the East and West Forks and Upper Chehalis, including around the proposed dam site. Toads were also found throughout the Satsop, Wynoochee, and Humptulips watersheds and, to a lesser extent, the Wishkah. No Toads were seen in the Skookumchuck or Newaukum watersheds despite substantial survey effort. Breeding activity included direct observations of egg masses as well as amplexing adults and recently-hatched tadpoles.

Our analyses found that, Basin-wide, Toad breeding, is on average positively correlated with forest cover and negatively correlated with stream temperature. However, our analysis found that Toad breeding is not consistently correlated with forest cover across individual watersheds or streams within watersheds. These analyses underscore the need for local- to landscape-scale analyses when investigating occupancy of Toads across a large and diverse region.

Toad breeding is associated with different environmental features depending on the scale of observation. Across the whole Basin (models naïve to variation among watersheds), we found a positive association between Toad presence and tree cover at the landscape (200-m buffer) scale but did not find the same to be true at the riparian (20-m) scale (**Figure 3**). When accounting for variation among watersheds in the Chehalis Basin, we found a positive – but variable – relationship between Toad breeding presence and tree cover at all rivers at the landscape scale (200-m) except the Satsop River, with the strongest relationship occurring in the Chehalis River (**Figure 4**). The relationship between tree cover and Toad presence is also positive at the riparian scale (20-

m) for the Chehalis River but somewhat *negative* for the Satsop and Wynoochee Rivers. The other rivers (Humptulips, Wishkah) show little relationship between Toad breeding and riparian forest cover. When river watershed identities are included in our models as a random effect instead of a fixed effect, the best supported model shows an overall Basin-wide positive correlation with landscape scale forest cover but weak negative correlation at the riparian scale.

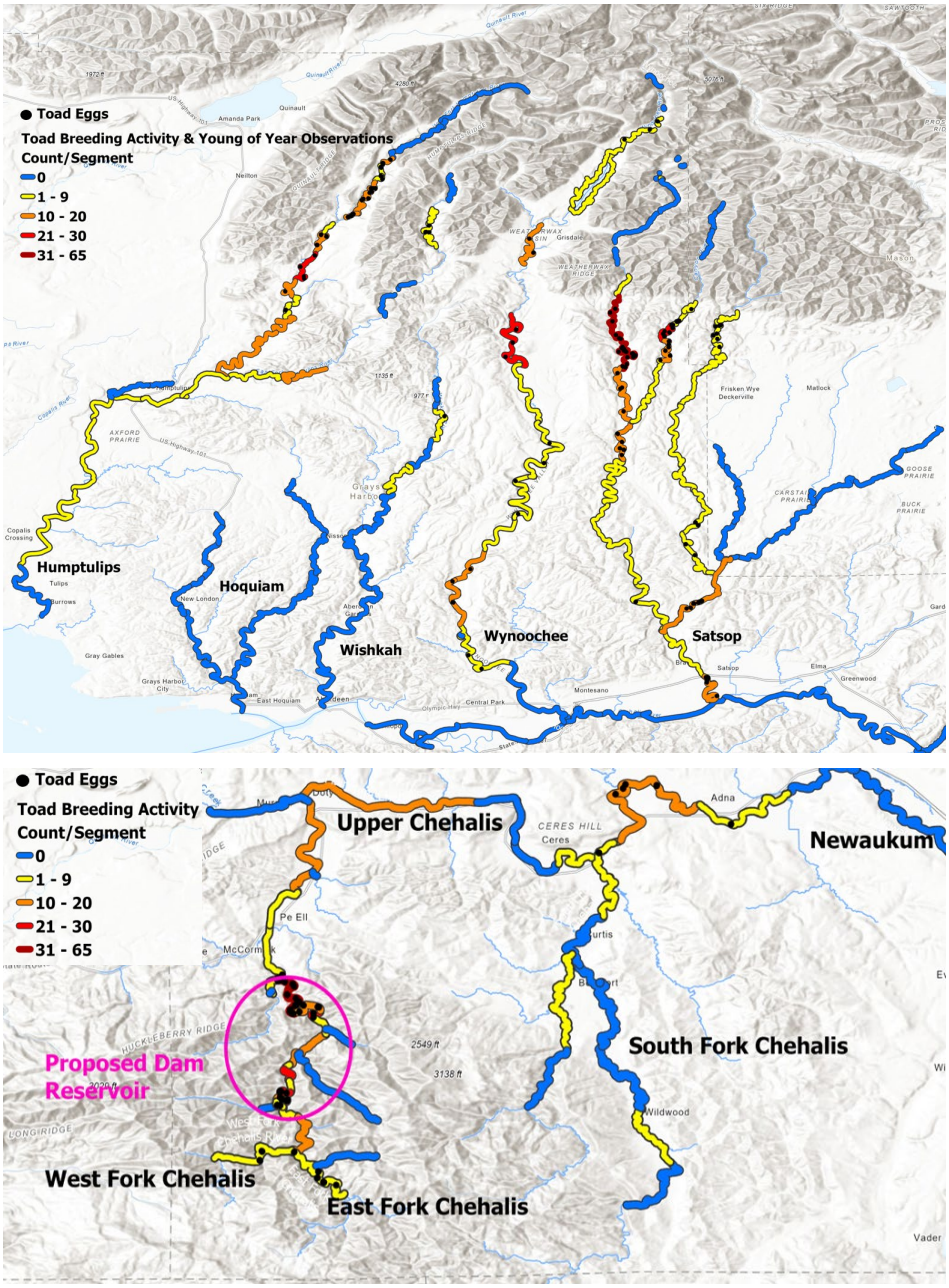

Figure 2: Toad breeding activity across the Chehalis Basin. Dots indicate egg mass locations whereas colors display breeding activity in general including egg masses as well as amplexing adults and tadpole swarms. No Toad breeding was observed on the Newaukum or Skookumchuck rivers.

Further, at the Basin-wide scale, Toad breeding is negatively correlated with stream temperature such that Toads have a higher probability of breeding at lower stream temperatures (**Figure 3**). Mean May temperature ranges from approximately 4 to 15°C across rivers. When accounting for differences among rivers (and controlling for forest cover), Toad presence is negatively correlated with stream temperature in the Chehalis, Humptulips, Satsop, and Wishkah rivers, with the steepest negative slope in the Chehalis and Wishkah rivers.

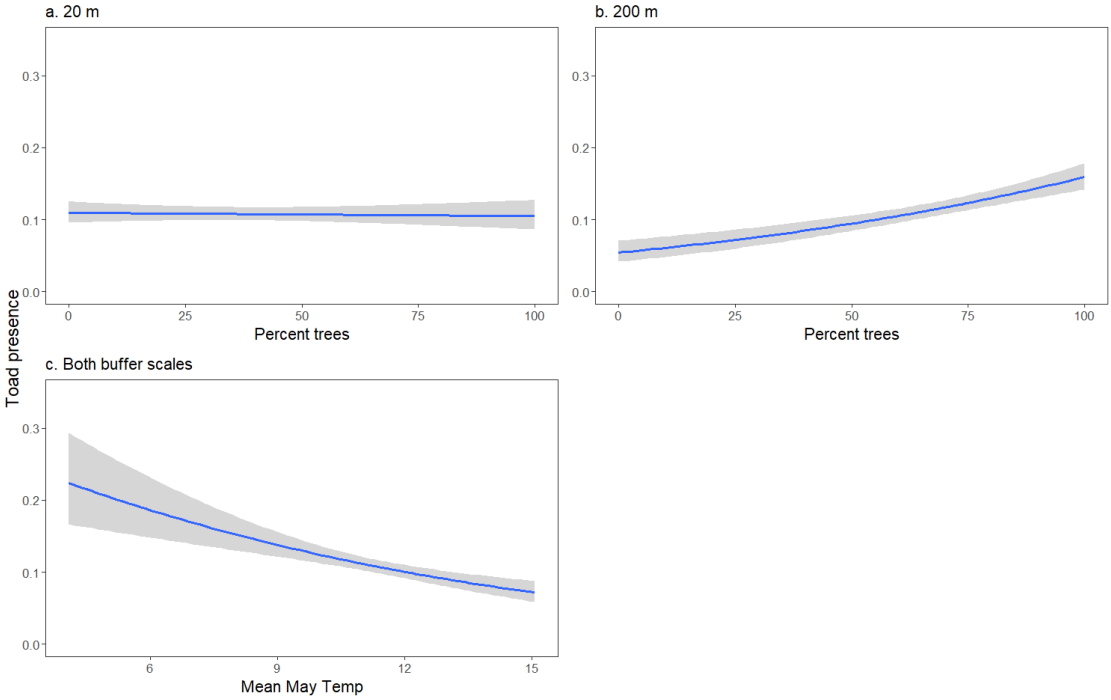

Figure 3. Basin-wide, Toad breeding is not associated with local, riparian (20-m) forest cover but is positively associated with landscape scale (200-m) forest cover. Breeding is also negatively correlated with stream temperatures Basin-wide.

Discussion

Our extensive surveying confirms that Western Toads in the Chehalis Basin overwhelmingly display an in-stream life history, a trait that largely contrasts with its biology elsewhere in its range. Based on the in-stream surveys reported here and studies in off-channel habitats in the mainstem Chehalis floodplain (Hayes et al. 2020) we have recorded Western Toad breeding in the Chehalis Basin almost exclusively in in-stream-associated habitats. Specifically, we have observed Toad breeding in the upper one-quarter of the Chehalis mainstem length, some larger tributaries above there (East and West Forks Chehalis River), and some larger tributaries of the middle and lower Chehalis mainstem (the South Fork Chehalis, Satsop, Wynoochee, and Humptulips Rivers).

The new analyses we present here underscore the value of assessing local and landscape scale habitat associations with an ASRP indicator species. Overall, our analysis finds a positive association between higher forest cover in the broader landscape surrounding streams and Toad breeding. Even so, that pattern differs markedly among watersheds within the Chehalis Basin. Specifically, there is a very strong positive association between landscape-scale forest cover and Toad breeding in the upper Chehalis watershed but less pronounced or even neutral

relationships between forest cover and Toad breeding in the Humptulips, Satsop, Wishkah, and Wynoochee watersheds. Riparian forest cover (within 20-m of the stream) is functionally not associated with Toad breeding.

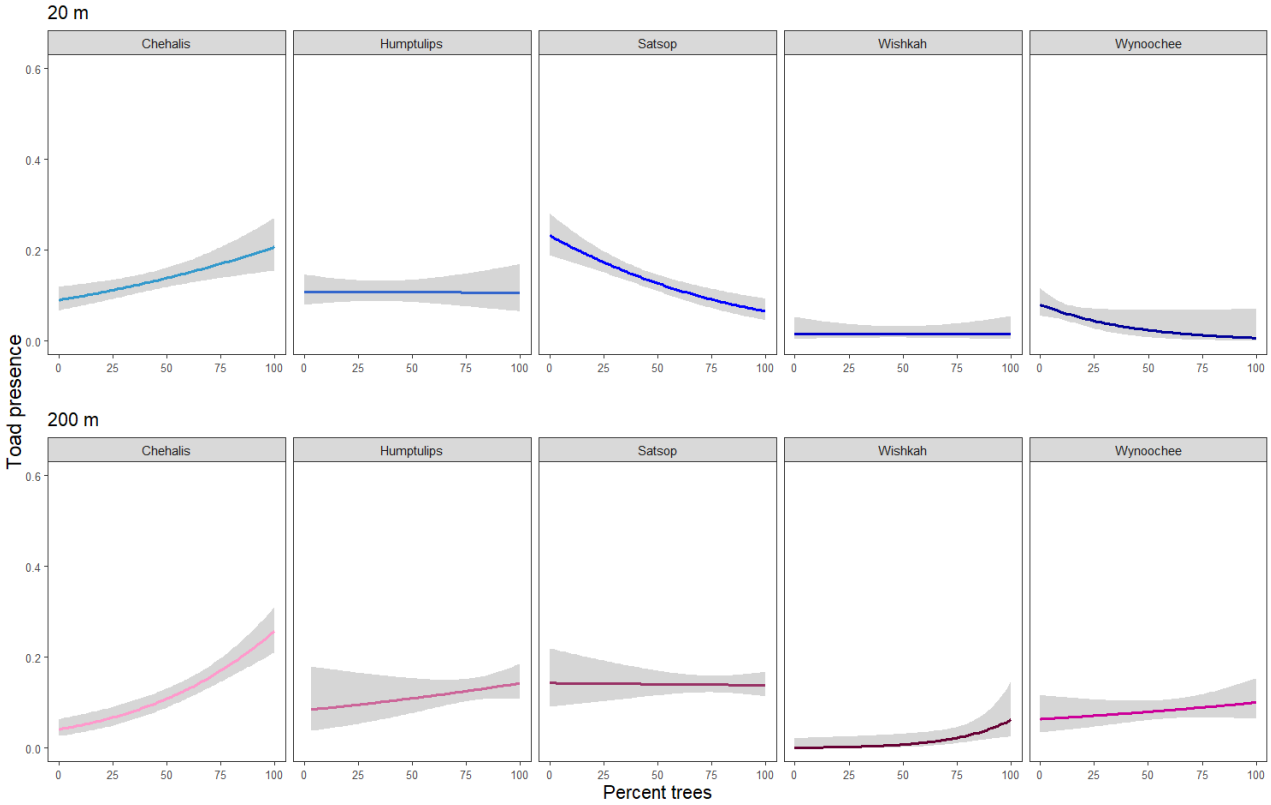

Figure 4. Toad breeding presence as a function of riparian (20-m) and landscape (200-m) tree cover across different Chehalis Basin watersheds.

Interestingly, several watersheds (Humptulips, Wishkah, Wynoochee) show little association between forest cover and Toad breeding. In contrast, the Toads in the Chehalis mainstem show a strong *positive* association whereas Satsop Toads show a strong *negative* association between riparian forest cover. From these patterns, we may conclude that generally protecting upland forest habitats will likely benefit Toad populations. However riparian forest buffers may have mixed effects on Toad breeding and may in cases conflict with other riparian forest goals if some streams or reaches benefit Toads with more insolated riparian areas.

Our prior analyses found that Western Toads breed in in-stream pools (largely to the exclusion of off-channel habitats) with a diversity of dimensions, depths, temperatures, and substrates. Even so, our analyses suggest that Western Toads favor microhabitats *within* pools that are shallow (below 20cm and often below 10cm deep) and slow moving (typically below 0.001 cm/sec). Future restoration activities targeted at Toads may benefit from targeting sites with these microhabitat conditions in addition to the broader habitat conditions identified by our recent modeling. Ongoing status and trends research is documenting whether Toad breeding is proportional to the availability of various habitat features on the landscape or whether Toads show preference for particular habitat conditions.

Adaptive Management

This work may influence decisions around protecting forest habitats surrounding known Western Toad breeding sites across the Basin. Specifically, although Toads appear to breed in in-stream pools that are well insolated, they require substantial forest habitat upland from the stream. Thus, forest protections around Toad breeding sites are likely valuable. However, the inconsistent association between riparian forest cover and Toad breeding among watersheds underscores the need for further research identifying why, for instance, the most heavily forested riparian shorelines have the highest Toad breeding in the Chehalis but the lowest Toad breeding in the Satsop. Future restoration activities targeted at Toads may benefit from targeting forest protection sites with the within-pool microhabitat conditions we have previously identified as valuable for Toad oviposition or by creating these conditions with artificial pools to enhance Toad breeding habitat availability.

Although our current data can inform the environmental distribution of inhabited Toad pools, our ongoing Status and Trends research is necessary to inform how environmental features across the landscape shape the distribution of Toad in the Chehalis Basin. Ongoing long-term monitoring is designed to understand the dynamic spatial and temporal distribution of Toad breeding given that stream conditions vary across seasons and years. Specifically, breeding site placement and abundance may vary year-to-year within a reach depending on, for example, flows or objects like large wood which can slow water. Findings from this ongoing work will inform the spatial extent of protected stream habitat needed to maintain or bolster Toad breeding habitat as well as which in-stream, riparian, and landscape conditions are most likely to sustain breeding and successful larval development.

Further, any habitat enhancement for Toads would be experimental in nature as we are unaware of no known Toad-specific restoration actions. Yet there may be opportunities to implement such experimental habitat actions within our long-term monitoring sites to create before-and-after restoration comparisons and test whether Toad habitat can be successfully improved. Doing so would leverage our place-based science to maximize the chance of restoration success and provide future guidance to the Steering Committee and project applicants Given our findings that Toad breeding typically overlaps with salmonids (especially Coho) and other fishes including lamprey, restoration actions that target Toad breeding will likely have co-benefits for fish life and Toad breeding may be a sensitive indicator of improved habitat conditions for these other stream species.

Finally, we have collected substantial data from the footprint of the proposed flood retention dam. These data have supported Environmental Impact Statement (EIS) assessments. Our work on this WA Species of Greatest Conservation Need and an ASRP Indicator Species will continue to be useful for ongoing discussions surrounding other potential flood control measures in the Chehalis Basin.