Springs and the minute snails that inhabit them in the Puget Sound region: Searching for the concealed

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As part of a phylogenetic study with Dr. David Campbell, Gardner-Webb University, NC on *Juga* and *Pristinicola*, I have been surveying springs for the latter snail in the Puget Sound basin. Permanent springs (by springs I also include seeps) are ones running year round for thousands, if not a million years or so, may occur singly or in groups and are not only an important habitat for freshwater mollusks, in particular snails, but for many other animals and plants, especially in arid areas. Springs have a disproportionate occurrence of rare or endemic species, some found at one or a few springs (Sada et al., 2001). Springs also serve as a thermal refugia for many species including springsnails, especially those that were unable to migrate rapidly enough as the climate warmed during the end of the last ice age (Late Pleistocene). I have found cold springs in the Puget Sound basin ranging from 11 to 13 ºC, approximately the current mean annual ambient air temperature in the region, indicating they are coming from a relatively shallow groundwater sources. Hopefully human caused climate change will not increase water temperatures of these springs above the tolerance threshold of springsnails or other taxa. In the opposite temperature spectrum, hot springs (actually warm springs, above 46 ºC is too hot) support freshwater snails and other animals that cannot exist at cooler temperatures and have deep seated groundwater sources (Sada et al., 2001; Clarke, 2014). I have found no thermophile snail species occurring in the Puget Sound region; only two cold-water taxa, *Pristinicola hemphilli* (Pilsbry, 1890) (pristine pyrg) and *Colligyrus* n. sp. (coastal duskysnail) have been found during my surveys of springs here and elsewhere **(Figure 1; Johannes, 2015)**. Recent DNA analysis suggest placement of the coastal duskysnail under a new genus (Liu et al., 2015). Both snails occur mostly in seeps to small-medium sized springs though on rare instances *Pristinicola* is found in small spring influenced creeks and bigger springs. To me, how these snails migrate from one spring, whether hot or cold, to another is a very interesting biogeographic problem, especially in the recently deglaciated Puget Sound basin. If you are inspired by finding new molluscan species, as I am, springsnails are by far the easiest way to go in the western U. S. Many have been scientifically described (mostly in the genus *Pyrgulopsis*) from this region within the last decades, with an unknown number yet to be found or named, including the aforementioned coastal duskysnail. Of the freshwater mollusks that occur in the western U. S., the few listed under the Endangered Species Act (ESA) include a significant number that are either spring dwellers or found in habitats influenced by springs or groundwater. Neither springsnail that occurs in the Puget Sound region are listed under the ESA. Despite the relative small size of the habitat, I have found searching for springs in the open arid lands of the western U. S. relatively easy. From a distance the green strip of vegetation surrounding the source and run of springs can be readily seen on hillsides or valleys **(Figure 2)**. Even U. S. Geological Survey (USGS) 7.5-minute topographic maps, also known as 7.5’ quadrangle, often have springs indicated in such areas, which are easily seen in areal photos, the basis for these maps. But areas with dense forest and vegetative cover, such as in the Puget Sound region, searching for spring habitats are extremely difficult **(Figure 3)**. Often the USGS 7.5’ quadrangles in this region do not show them–even large ones with names, like Crystal Springs (N.-most site for *Pristinicola* in Puget Sound) occurring a half mile from my house, are missed. So what is one to do?

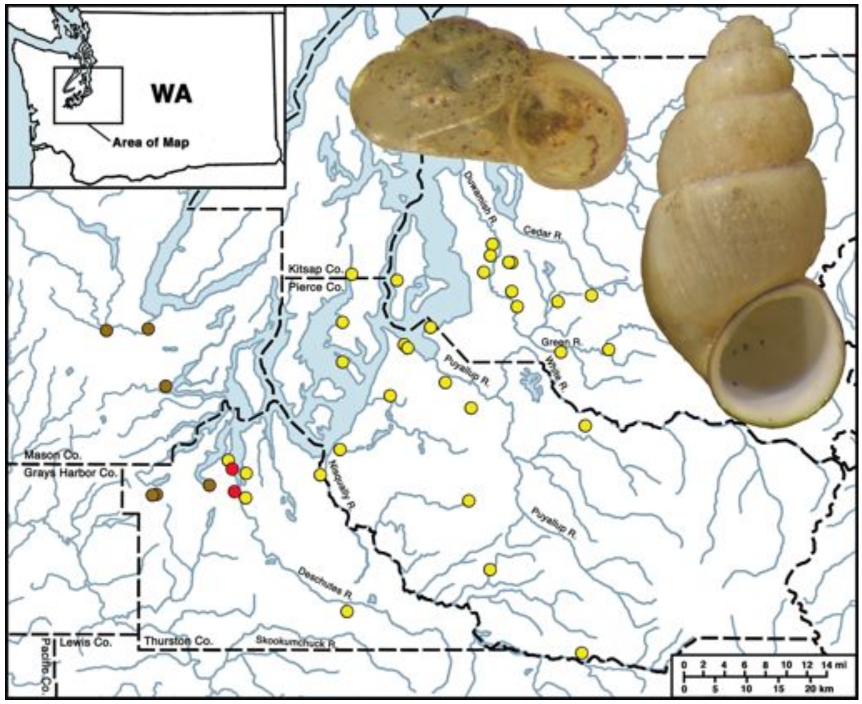

Figure 1. Map showing distribution of *Pristinicola hemphilli* (yellow dots) and *Colligryrus* n. sp. (brown dots) in the Puget Sound basin. Red dots sites where they co-occur. Insets of *Colligryrus* n. sp. (coastal duskysnail; no other western U. S. hydrobioid has a near planispiral shell like this minute species; height 1.2 mm) on the left and *Pristinicola hemphilli* (pristine pyrg; height 2.8 mm) on the right. Both at same scale.

From experience I know that most springs emanate from the side or base of hillsides, or along drainages often in small stream ravines or gulches. These are good geographic features to narrow searches. Permanent springs in the Puget Sound basin depend on a big enough upland (catchment) area for rain to fall on, that are underlain mostly by permeable geologic units largely glacially deposited allowing infiltration to a sufficient depth before hitting impermeable layers to store enough underground water volume for year round flow even during the dry summer months. But searching (crashing through) all

Figure 2. Left photo: Springs (green strips) on the Washington side of the Columbia River Gorge west of Wishram. Right photo: Spring on the Oregon side of the Columbia River Gorge west of Celilo Village. All too common livestock are allowed access to spring sources degrading them. Photos taken at the same vantage point along side Wasco County Road 143. *Juga* n. spp. and *Pristincola* occur in springs in this region.

Figure 3. Left photo: Well concealed spring run near county boundary sign with *Colligyrus* along Cloquallum Road, Chehalis River drainage, Grays Harbor County. Yellow flowers (pointer) of skunk cabbage revealed presence of spring. Photo T. Frest. Right photo: Concealed spring with *Pristinicola* along Chatwood Road SE, Deschutes River drainage, Thurston County. Note the presence of devils club, horsetails and water parsley. Drew Skinner for scale.

these well-vegetated slopes and ravines for springs would be slow going. If they exist, looking at geologic maps may help whittle down the search area, but is dependent on prior knowledge of which units produce springs. Even then it does not tell you where the springs will occur in these units that could cover many square miles. Once again we are back to vegetation, obscuring the geology of this region further hindering searches. There seems to be a consistent theme here, vegetation. Instead of considering it a barrier, why not use it. That is exactly what I do. Instead of looking for springs, I look for specific kinds of vegetation on slopes and in ravines, ones that are wetland indicators (for practical guide see Cooke, 1997). This is especially useful while tooling along roads both in the actual sense or virtually when using Google Earth street view, as plants are easier to see than the springs they obscure. Another method I use is to watch for water in ditches during the dry summer months as a possible indicator of springs. But ditches are not always present along roads and during the rainy season are not as helpful indicator as is the presence of wetland plants.

I am not the first to use plants as indicators. Having a background in geology, I was aware that miners have known since medieval times particular plants could be used as indicators to the presence of ore bearing deposits. Both *Lychnis alpina*, a small pink-flowering plant in Scandinavia, and *Haumaniastrum katangense*, a white-flowered shrub in central Africa, were known associates of copper mother lodes. Recently, a tree, possibly *Pandanus candelabrum*, in Liberia was noticed to occur only in kimberlite soils, becoming the first indicator species for diamond-bearing kimberlite pipes (Haggerty, 2015). Before this, diamonds in Liberia were mined only from placer deposits and their sources could not be found, hidden not only by the thick tropical vegetation, but also ironically by dense impenetrable thickets of *Pandanus* trees. Here in the western U.S. the nickel-chromium bearing serpentinite rocks in the Klamath and Siskiyou mountains of Oregon and California have endemic plants, such as the carnivorous *Darlingtonia californica* (California pitcher plant), that grow no where else. Terrence Frest (deceased, my former Deixis Consultant partner and a PNWSC member), while surveying the Midwest Driftless area during the 1980's for the ESA listed Endangered *Discus mcclintockii* (F. C. Baker, 1928) (Iowa Pleistocene snail), used both geology to define the extent of his search area and vegetation to zero in on a rather locally narrow habitat where this and several other glacial relict land snails occurred (Frest, 1984, 1991). He called this habitat algific talus slopes (Frest, 1981). He had noticed that algific talus slopes consistently occurred in two separate Paleozoic limestone formations, both with thin shaley layers that allowed periglacial frost and ice wedging of limestone blocks on N.-facing slopes during the close of the Wisconsinan (Late Pleistocene). This created a mechanical karst where ice could accumulate during the winter months resulting in year round refrigerated talus slopes, the talus debris falling from the cliff faces. This created a rather stable microclimate that not only protected the glacial relict land snails from climate change at the end of the last ice age, but also allowed both relict and disjunct plants and trees to exist in the Midwest that would otherwise be extinct or found further north in Canada. Using geologic maps, he determined what hillsides the Paleozoic formations cropped out on and could quickly find these small habitats by searching for occurrences of specific trees such as Canada yew, balsam fir, birch, basswood and sugar maple or plants, especially the ESA listed Threatened *Aconitum noveboracense*, northern wild monkshood. Using his method, he and later others were able to discover over three hundred sites within a relatively short time, this when previously only a couple of sites had been found after extensive searches over many years. Most sites are now included in The Driftless Area National Wildlife Refuge created to protect the Iowa Pleistocene snail and northern wild monkshood.

Unlike the examples given above, most of the plants occurring in the Puget Sound region that are wetland indicators are not necessarily restricted to spring habitats. Occurrence of these plants on slopes, slope bases or ravines improves the chances they actually indicate the presence of springs. There are only three plants I often find closely associated with springs–two of them painfully make me wonder why nasty plants are found at springs. These would be *Rorippa nasturtium-aquaticum* (watercress), a widely introduced European plant that prefers cool permanent water such as spring runs or ditches fed by springs; *Oplopanax horridus* (devil's club), with fine irritating spines on stems and leaves; and finally *Urtica dioica* (stinging nettle), with hollow stinging hairs on leaves and stems that can inject a irritating histamine into your skin. I have observed *Allogona townsendiana* (I. Lea, 1838) (Oregon forestsnail) often co-occurring with the last plant at springs **(Figure 4)**. It has been suggested that this landsnail has a strong affinity for *Urtica*, but I think springs have been overlooked as an important factor also (Waldock, 2002). I believe *A. townsendiana* is a glacial relict, preferring a stable cool microhabitat offered by springs, somewhat like the algific talus slope landsnails do in the Midwest. Other wetland plants I often look for include *Lysichiton americanum* (skunk cabbage), which has smelly yellow flowers; *Oenanthe sarmentosa* (water parsley), reported to be poisonous, can be found in spring runs or spring influenced small creeks; *Typha* spp. (cattails) often found in ditches with permanent water; *Cicuta douglasii* (western water-hemlock) is poisonous, do not eat; and *Mimulus guttatus* (common monkeyflower). Ones I don't trust as much to indicate springs include *Carex* spp. (sedges) and *Equisetum* spp. (horsetails) but they do indicate slopes that are wetter than typical and suggest the possibility of springs in the area. They also do occur at springs. As you can see the list of wetland indicator plants I use is not very extensive and learning to recognize them in the field is not difficult. So, if surveying for springsnails in the Puget Sound basin, don't look for the spring, look for the wetland indicator plants.

Figure 4. *Allogona townsendiana* found associated with a spring and *Urtica* on E. side of Waldrick Road SE near Silver Spring, Deschutes River drainage, Thurston County. Snails about 27 mm wide. Photo Bert Bartleson.

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