The current paper identifies family-level aquatic macroinvertebrate communities that respond to variations in streamflow duration in Idaho and Washington streams. The recommended taxa list will serve to compliment a multimetric assessment method designed to allow field practitioners to classify perennial, intermittent, and ephemeral stream habitats.
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INTRODUCTION

Purpose and Scope
The primary objective of this study is to develop an aquatic invertebrate taxa list and community composition indicators for evaluating streamflow duration in Pacific Northwest streams. The recommended invertebrate taxa list will be part of a multimetric assessment process that includes other biotic and abiotic indicators and is intended to allow field practitioners to delineate stream type differences in relation to their flow duration in Idaho and Washington streams. For ease of verification in the field, recommended macroinvertebrate indicators are identified to family level. Invertebrate taxa lists for both Idaho and Washington were informed by peer-reviewed literature, evaluation of regional stream assessment data, and consultation with regional and national experts. Our challenge is to identify macroinvertebrate taxa that respond to variations in streamflow duration throughout Idaho and Washington streams.

CHALLENGES & CONSIDERATIONS

Several confounding factors should be considered when characterizing stream habitats using aquatic macroinvertebrate assemblages and attempting to delineate differences between perennial and temporary streams. These challenges were summarized previously in work done to determine streamflow duration in Oregon (Mazzacano and Black, 2008), and they hold true for the additional Northwestern states into which this work is being expanded.

Streamflow regime is recognized as the principal variable affecting the success and distribution of aquatic macroinvertebrates (Poff and Zimmerman, 2010), yet relatively few studies specifically examine streamflow duration in relationship to biotic assemblages in ephemeral versus intermittent and perennial streams (Savage and Rabe, 1979; Jacobi and Cary, 1996; Price et al., 2003; Bonada et al., 2007; Clarke et al., 2010; Santos and Stevenson, 2011). Patterns of streamflow as they relate to biological parameters are frequently described only in studies documenting the effects of drought and flood disturbances (Konrad et al., 2008). Furthermore, there is a paucity of information on the adaptations of macroinvertebrates to intermittent streamflows and their use of refugia during these stressful conditions (Robson et al., 2011). This limited knowledge of the effects of intermittent drying on stream biota introduces complications when comparing biological integrity of these streams to perennially flowing streams. Richards (2010) concedes in a preliminary study of intermittent streams in Idaho that specific scoring criteria and biological metrics need to be developed to account for the natural variability in aquatic macroinvertebrate communities of temporary streams. Moreover, few studies have quantified the effects of flow duration across different ecoregions (Chinnayakanahalli et al., 2011) or have described how this relates to invertebrate communities in streams of differing flow durations.

A considerable body of published work has addressed aquatic invertebrates of lotic communities in relation to their distribution between streams of variable flow regimes (i.e., high flows vs. flow diversions and flow predictability vs. flow variability) in Idaho (e.g., Minshall and Winger, 1968; Andrews and Minshall, 1979; Robinson et al., 1993; Robinson and Minshall, 1998), though limited studies address the results of restricted flow duration and the consequences of no flow events for biotic communities. These studies compare macroinvertebrate communities and their responses to disturbance in perennial streams.
A rare preliminary study by Richards (2010) for the Idaho Department of Environmental Quality was done to compare macroinvertebrate communities of intermittent montane streams to those of nearby perennial streams. Preliminary findings suggest that macroinvertebrate assemblages are substantially different in intermittent streams when measured against comparable perennial streams in Idaho. In addition, intermittent streams harbored mostly short-lived taxa, with rare and uncommon taxa making up a large proportion of the fauna. Similar findings from other geographic regions have discovered that the diversity of taxa (usually at a coarse scale of taxonomic resolution such as family or order) is greater in perennial streams compared with intermittent (Feminella, 1996; Williams, 1996; Wood et al., 2005; Progar and Moldenke, 2002; Williams, 2006). In Richards’ study, the number and density of taxa increased during spring to summer; preliminary results point to diminished flows in combination with time (date) as the second best predictor of assemblage similarity. Furthermore, investigations in Washington streamflow studies reveal that, despite the abundance of seasonal, non-fish bearing headwater stream systems in the state, there is a lack of studies on the aquatic invertebrate fauna characteristic of low order temporary streams, as well as taxa response to flow duration.

The issue of classifying stream types based on macroinvertebrate fauna is confounded further by the fact that definitions of stream type are not standardized among different practitioners. Some authors type ephemeral streams as episodic temporary streams with variable flow patterns (sensu Argyroudi et al., 2009), while others introduce their own set of terms to classify intermittent and ephemeral streams (Uys and O’Keefe, 1997; Price et al., 2003; Clarke et al., 2010; Grubbs, 2011; Santos and Stevenson, 2011) or are unclear in the basis of their classification (e.g., Adams, 2000). Additional complications are created by conflicting definitions throughout different regions of the U.S. and different criteria for classifying stream types based on their flow duration (D. Carlisle, pers. comm.). The State of Idaho defines intermittent streams as those that have a period of “zero flow for at least one week during most years” (Davis et al., 2011). Additional discrepancies in stream classification systems involve hydrographic data sets that have been analyzed by researchers and found to incorrectly type intermittent streams as perennial (Davis et al., 2011; D. Carlisle, pers. comm.).

Although bioassessment inventories may be done routinely for perennial waters, very few are available for temporary streams (Williams, 2006; D. Carlisle, C. Konrad, and I. White, pers. comm.). This fact has been evident in the paucity of comparative studies in the literature for the Pacific Northwest as well as in hydrological and biological data sets. Despite an effort to gather hydrological flow duration data calculations for Washington streams (hydroperiod calculations courtesy of C. Konrad, USGS NWIS data), data analysis revealed no biological data (USGS BioData) were sampled at any of the non-perennial sites, further validating indications that most bioassessment studies avoid sampling in temporary streams.

In a further attempt to glean biological datasets from non-perennial streams, biological macroinvertebrate data (BioData) for Idaho and Washington was linked to the National Hydrography Dataset (NHD) to compare the aquatic communities in perennial, intermittent, and ephemeral streams in these states. Given the limitations with the classification of stream types in the NHD dataset, the use of this data is considered a last resort for a comparative analysis of macroinvertebrates in perennial versus intermittent and ephemeral streams (D. Carlisle, pers. comm.). Analysis for Idaho and Washington revealed that...
whereas comparatively more macroinvertebrate samples had been taken from perennial streams, only a small number of NHD intermittent sites contained BioData samples, and no streams coded as ephemeral had biological data associated with them.

INVERTEBRATE COMMUNITIES – PERENNIAL vs. TEMPORARY WATERS

Commonality between Perennial and Non-perennial Streams

Results of many comparative streamflow studies reveal some degree of commonality between macroinvertebrate assemblages of intermittent and perennial streams (Williams and Hynes, 1976b; Wiggins et al., 1980; Delucchi and Peckarsky, 1989; Dieterich, 1992; Feminella, 1996; Shivoga, 2001; Progar and Moldenke, 2002; Price et al., 2003; Stubbington et al., 2009; Grubbs, 2011). Arscott et al. (2010) maintain that variations in taxa due to decreases in hydroperiod are not a result of selection for specialist species, but a consequence of cumulative removal of desiccation-sensitive taxa. In this study, macroinvertebrate communities at non-perennial sites were subsets of the communities at perennial sites, with large-bodied, long-lived organisms such as mollusks showing reductions in numbers as streamflow duration decreased. Similarly, in other studies increasing streamflow permanence had a positive correlation with macroinvertebrate diversity and richness (Feminella, 1996; Williams, 1996; Smith et al., 2003; Williams, 2006; Clarke et al., 2010), further suggesting that subsets of perennial-obligate taxa drop out as flow duration decreases. However, still other studies have reported similar diversity and richness among the aquatic macroinvertebrate communities of non-perennial and perennial streams (del Rosario and Resh, 2000; Dieterich and Anderson, 2000; Santos and Stevenson, 2011). Wiggins et al. (1980) proposed that temporary aquatic habitats feature generalists that may be widely distributed in other aquatic habitats, including perennial waters, while also possessing adaptations to survive during desiccation events. Further evidence of taxa overlap in streams with contrasting flow duration is represented frequently at the coarse family-level scale, while at the species level individual taxa may be characterized as indicators of streamflow duration and unique to specific stream types (e.g., Wright et al., 1984).

In a study of temporary and perennial streams in western Oregon, taxonomic richness was consistently higher in perennial streams as was the total density and biomass of aquatic insects (Progar and Moldenke, 2002). Accordingly, comparisons of long-term flow regime throughout streams in the western U. S. revealed that overall, interruptions in flow were the most significant descriptors of macroinvertebrate richness (Chinnayakanahalli et al., 2011). An analysis of non-perennial streams in the northeastern U.S. found that macroinvertebrate richness was similar between perennial and intermittent stream sites, while ephemeral streams were comparatively lower in species richness (Santos and Stevenson, 2011). Overall, similar studies find that, during periods of flow, non-perennial streams support a diverse fauna frequently found to rival the biodiversity of perennial streams (Clark et al., 2010).

Disturbance in the form of water withdrawals was studied on the Umatilla and 11 other rivers in northeastern Oregon and southeastern Washington, a region with a hydrologic history of occasional intermittency and low flows (Miller, 2007). Discharge reductions over 90% of ambient levels were related to community shift from a dominance of EPT taxa (Ephemeroptera, Trichoptera, and Plecoptera) to a predominance of predatory insect and non-insect species (Miller, 2007). In this study, drought coupled
with increased water withdrawals and subsequent increased temperatures on the Umatilla River was responsible for shifts in community attributes with decreases in stoneflies (Perlodidae and Perlidae) and mayflies (Heptageniidae, Leptophlebiidae, and Baetidae), although winter high flows allowed recolonization by these taxa (Miller, 2007).

Although there is some overlap in EPT taxa between perennial and temporary streams, their abundance and diversity is greater in permanently flowing streams. This was true for perennial and temporary streams sampled in Washington, where EPT taxa sampled as part of the BioData dataset represented 34% of the taxa sampled in perennially coded streams and 28% of the taxa in intermittent streams within the NHD dataset. Analysis of perennial stream BioData samples for Idaho NHD streamflow data revealed that out of 1713 individual taxa sampled from perennial streams, 990 were EPT. Of 313 taxa sampled in intermittent streams, 203 were EPT taxa. The similar proportions of EPT in this dataset provides additional evidence that the life histories of some mayfly, stonefly and caddisfly families allow them to successfully exploit temporary habitats in the Pacific Northwest. However, due to the under-sampling of temporary streams, it is difficult to make accurate and direct comparisons of intermittent and perennial taxa with BioData and NHD datasets.

**Perennial-associated Taxa**

The use of an EPT metric (Ephemeroptera, Plecoptera, and Trichoptera) is a well-known and commonly employed indicator of the biological integrity of perennial streams (e.g., Barbour et al., 1999; Karr and Chu, 1999; Rosenberg et al., 2008). Many comparative studies confirm that there is an incremental increase in the number of EPT taxa along a gradient of streamflow permanence (e.g., Bonada et al., 2007; Arscott et al., 2010; Clarke et al., 2010), suggesting that this index may prove useful as a metric for streamflow classification. Some stonefly families such as the Perlidae (common stoneflies) and Pteronarcyidae (giant stoneflies) have specialized habitat requirements, require more than one year to complete larval development, and are considered indicators of cold-water perennial streamflows (Stewart and Stark, 2002, 2008). In a stream biological assessment, Plotnikoff (1998) identified use of these two stonefly families as biological indicators of stream health, and their presence was also related to diagnosis of perennial flow. Conversely, absence of these long-lived, semi-voltine taxa was suggestive of an intermittent stream community composed of univoltine or multivoltine taxa (Plotnikoff, 1998), providing further evidence of their efficacy as indicators of streamflow permanence.

Highly rheophilic families such as Rhyacophilidae (Trichoptera), Glossosomatidae (Trichoptera), Perlidae (Plecoptera), Pteronarcyidae (Plecoptera), and Psephenidae (Coleoptera) strongly prefer perennial lotic environments and this in general is true across the U.S. (J. Kennen, pers. comm.). Similarly, although many Odonata (dragonflies and damselflies) families are well-adapted to seasonal habitats, gomphid (clubtail) and cordulegastrid (spiketail) dragonflies and calopterygid (broad-winged) damselflies in the Pacific Northwest prefer perennial streams. Gomphids displayed “extremely limited tolerance for intermittence” (sensu Feminella, 1996) in a comparative study of aquatic macroinvertebrate assemblages in several small upland Alabama streams, and were also classified as prominent indicators of perennially flowing streams in a study of temporary and permanent Mediterranean streams (Garcia-Roger et al., 2011).
Taxa Adapted to Intermittent Flows

Many Trichoptera (caddisfly) taxa are also restricted to perennial waters, but some families in this order possess adaptive life cycle strategies and attributes, including multivoltinism and desiccation-resistant life stages, which allow them to survive the periodicity of in-stream flows (Wiggins, 1996; Wiggins and Currie, 2008). Other traits characteristic of desiccation-resistant species include small body size; egg, larva, or adult diapause; body armoring; mucus secretions; timed emergence and emigration or dispersal; timed growth during the pool phase; air breathing; and aestivation in the hyporheos. A study by Adams (2000) describing the macroinvertebrate fauna of seven temporary streams in Washington sampled during periods of streamflow found capniid and nemourid stoneflies as components of the aquatic fauna within these reaches. Plecoptera as a group appear less adapted to standing water conditions than to drought and as a consequence persist through drought mainly in lotic habitats as diapausing nymphs (Williams, 1996).

Many other temporary stream studies find specific families of stoneflies (e.g., Nemouridae, Capniidae) and caddisflies (e.g. Limnephilidae) significantly associated with temporary habitats (e.g., Harper and Hynes, 1970; Lehmkühl, 1971; Williams and Hynes, 1976a; Delucchi and Peckarsky, 1989; Jacobi and Cary, 1996; Dieterich and Anderson, 2000; Smith and Wood, 2002; Price et al., 2003; Williams, 2006; Richards, 2010; Garcia-Roger et al., 2011). Members of these families have been shown to possess adaptations that allow them to survive desiccation events. Wiggins et al. (1980) documented limnephilid caddisflies in temporary pools and characterized them as over-wintering summer recruits generated by adults that oviposit on the dry streambed, suggesting they may overwinter in diapause as eggs or early instar larvae. Dominant, common taxa from intermittent streams in an Idaho study included Diptera and Ephemeroptera, with Diptera increasing and Ephemeroptera decreasing as the drying season progressed (Richards, 2010). This study also determined that about 2/3 of intermittent stream samples were composed of univoltine and multivoltine taxa, indicating that intermittency is less favorable for long-lived taxa that may become extirpated as a stream dries. Overall, baetid mayflies comprised the highest proportion of taxa sampled from the twelve intermittent streams, while nemourid and capniid stoneflies accounted for 25% and 17% of taxa in 12 streams that were sampled, respectively.

Other orders commonly associated with temporary habitats and found in greater abundance in non-perennial streams are Coleoptera (beetles) and Hemiptera (true bugs), including families such as Hydrophilidae (water scavenger beetles), Dytiscidae (predaceous diving beetles), and Notonectidae (backswimmers). Members of these orders are strong fliers that are highly effective dispersers as adults, and are known to exploit and colonize a variety of temporary habitats (Williams and Hynes, 1976a; Garcia-Roger et al., 2011). Their specialized life histories enable them to survive as desiccation-resistant eggs, burrowing as adults, pupating in semi-terrestrial habitats, and timing adult emergence prior to stream drying (Williams, 2006). Dytiscid (Agabus) and hydrophilid (Helophorus) beetles comprised 42% and 17% of all 12 streams sampled in a study of intermittent streams in Idaho (Richards, 2010), respectively. Both families are known to be diverse and common in pools and slow-flowing waters of streams with aquatic vegetation (McCafferty, 1998; Larson et al., 2000; White and Roughley, 2008).

Among the Mollusca, pulmonate snails that are capable of breathing atmospheric air such as physids (bladder snails) and planorbids (ram’s horn snails) have been recorded in several temporary stream habitats which experience periods of drying. Wiggins et al. (1980) found physids in temporary habitats in...
southern Ontario and noted that some snails, as overwintering permanent residents, presumably survive the dry phase by forming a mucoid covering around the aperture of the shell. In this same study, both physids and planorbids were designated as permanent, overwintering residents that aestivate as adults in the dry basin of temporary habitats. Additionally, Williams and Hynes (1976a) found physids and planorbids in a southeastern Canadian stream that dried for five months out of the year.

SPECIAL CONSIDERATIONS FOR THE PACIFIC NORTHWEST

Idaho, Oregon, & Washington
Due to the ubiquitous nature of stream macroinvertebrates from similar habitats around the world, it is no surprise that streams throughout the diverse ecoregions of the Pacific Northwest share common elements among their taxa, especially at the family level. Information gathered from the literature and stream datasets for macroinvertebrates in Pacific Northwest streams reveal a great deal of similarity among the fauna inhabiting Oregon, Washington, and Idaho streams. Savage and Rabe (1979) described differences of representative aquatic macroinvertebrates that reflected distinct physical attributes of three perennial streams in Idaho. Consequently, analysis at the family level for this study revealed similarities in EPT taxa across these perennial stream types, as heptageniid and baetid mayflies, perlodid stoneflies, and rhyacophilid and hydropsychid caddisflies were sampled throughout perennial streams, even though they differed in gradient and substrate. Indeed, similarities exist at the family level for aquatic macroinvertebrates in temporary streams from a variety of geographic regions around the world (Williams, 2006) and many stream taxa in the western U.S. share the same genera and physical characteristics as their counterparts in the east (J. Kennen, pers. comm.). However, it should be noted that considerations for streamflow indicator taxa may be confounded by the fact that aquatic macroinvertebrate communities are also structured by physical features such as gradient, substrate, and stream order, as well as by flow duration. In addition, the spatial position of a stream can serve to impede or reduce the colonization rate of stream insects, increasing time of recovery after drying (Richards and Minshall, 1992) and influencing the macroinvertebrate assemblage following a disturbance event.

Regional Considerations for Indicator Taxa
Although comparative perennial and temporary macroinvertebrate indicator stream studies are lacking for both Idaho and Washington, the ubiquity of insect taxa identified as indicators of streamflow in the Oregon report by Mazzacano and Black (2008) allows for similarities across regions of the Pacific Northwest. Despite this, regional caveats should be considered for macroinvertebrate indicator families.

Regional considerations should be noted for certain perennial and intermittent taxa in the Pacific Northwest:

Odonata:
Gomphid dragonflies are found mainly in larger rivers and streams, and are less likely to be found in high-gradient forested headwater streams in the Pacific Northwest. Gomphids are also less likely to be found in western Washington and western Oregon, though Gomphus kurilis, Octogomphus spp., and Ophiogomphus bison are all common in warmer southwestern Oregon streams (D. Paulson, pers. comm.). Many members of the Gomphidae family are not indicated in species distribution maps as occurring in the far corners of southern Idaho (Paulson, 2009). However, because natural history information for
dragonflies in southern Idaho is limited, D. Paulson (pers. comm.) maintains that he is confident
gomphids are widespread in this area in lower elevation perennial river systems (Lung and Sommer,
2001) and throughout the state.

**Mollusca:**
Southern Idaho has a diversity of imperiled mollusks, but little is known of their distribution and
abundances in the state. Additionally, no research on the diversity of native freshwater mollusks in
intermittent streams has been conducted in Idaho (Richards, 2010).

Some gaps in our current knowledge of freshwater mussels in Idaho can be addressed by recent reports
from surveys of *Margaritifera falcata* in the Idaho panhandle (D. Stagliano, pers. comm.). Reports from a
regional conference in the Pacific Northwest also indicated that populations of *M. falcata* have been
found at higher elevations than previously known in the Pacific Northwest, including some at over 7,000
feet (D. Stagliano, C. Mazzacano, pers. comm.).

In Oregon and Washington, the pleurocerid snail genus *Juga* is common in the lower elevations of
the southern coastal and valley streams but rarely found east of the Cascade Range (Hawkins and Furnish,
1987). In sharp contrast, pleurocerids are absent from Idaho streams (S. Lysne, pers. comm.). Other
common mollusks restricted to perennial streams in the Pacific Northwest include hydrobiid (mud snails)
and ancylid (freshwater limpets) gastropods.

Bladder snails (physids) and ram’s horn snails (planorbids) are pulmonates that can be found in Idaho’s
intermittent stream habitats (S. Lysne, pers. comm.). Indications from S. Lysne are that “mollusks in
Idaho to my knowledge are not found in ephemeral streams that dry for weeks or longer”. This
information conflicts with reports from eastern Washington east of Yakima where physids and planorbids
have been observed in dry sediment of ephemeral streams (R. Plotnikoff, pers. comm.). This may indicate
either a lack of knowledge of mollusk distribution in Pacific Northwest streams or regional caveats that
should be considered for different states. Because information is limiting, further sampling should be
conducted in temporary streams to help inform the designation of physids and planorbids for Idaho,
Oregon, and Washington streams.

**Changes from the Oregon Indicator Taxa List**

**Odonata:**
Although none of the species in the genus *Lestes* (Lestidae) are characteristically stream species and
damsselflies are not a notable component of stream ecology in the Pacific Northwest, pools formed during
the drying of an intermittent stream may be able to provide temporary habitat for these otherwise lentic
taxa, given the presence of aquatic vegetation to support oviposition (D. Paulson, pers. comm.). Indeed,
eggs of lestid (*Lestes*) odonates have been found in one study in different development stages in
temporary pools in an intermittent creek in Canada (Williams and Hynes, 1976a). Other papers explain
that certain lestid odonates survive dry periods in a desiccation-resistant egg and resume development
once flows return (Williams, 1996; Corbett *et al*., 2006). Stream damsels (*Archilestes* spp.) in the family
Lestidae comprise two species with limited distribution in the Pacific Northwest, only one of which, *A.
californicus*, is present in the OR-WA-ID region. This species is widespread in Oregon but present in
Washington with limited distribution (south central and southeastern Washington), and is known only
from a small eastern portion of the Idaho panhandle (although this may reflect a paucity of search effort and reporting). Because of these considerable caveats and the limited information of lestid distribution in Oregon and Washington intermittent streams, Lestidae are considered region-limited and may only be applicable as intermittent indicators for Oregon streams.

**Megaloptera:**
Initially both Corydalidae (dobsonflies and fishflies) and Sialidae (alderflies) were included as perennial indicators of streamflow duration for Idaho and Washington. In the Pacific Northwest, Corydalidae require from two to five years to complete their development (Evans, 1972), linking them firmly with perennially flowing waters. The Sialidae are less tightly tied to perennial streams as they complete the aquatic phase of their development in one year and are not considered as effective perennial indicators. Use of the Corydalidae as a perennial indicator for Idaho and Washington streams should be equally valid for Oregon stream assessments. It should also be noted that while Megaloptera may be widespread throughout the Pacific Northwest, they tend to be present at low abundance in streams where they occur (S. Hubler, pers. comm.).

**New Metrics:**

**Ratio of EPT to OCH taxa:**
Bonada *et al.* (2007) suggested that the relationship between the number of EPT taxa and the number of OCH taxa (Odonata, Coleoptera, and Hemiptera) changes across the gradient of streamflow permanence, with a decrease in EPT and concomitant increase in OCH taxa as a stream’s flow moves from perennial to temporary. A change in community composition at the beginning of the dry period from EPT (rheophilic) to OCH (lentic) taxa has been indicative of decreased streamflow and creation of pools as drying advances (Feminella, 1996; Boulton, 2003). Thus, a new metric of EPT/OCH is suggested for use to delineate the perennial-intermittent boundary; however, it may not be useful to ephemeral classification as EPT are not expected or may occur in low abundances in this stream class. The EPT/OCH metric is also recommended as an applicable metric for Oregon streams.

**Presence of rat-tailed maggots (Syrphidae):**
Presence of rat-tailed maggots has been added along with mosquito larvae as an indicator of ephemeral streamflow. Because most mosquitoes obtain atmospheric oxygen by using their respiratory siphon at the water’s surface, they are not reliant on dissolved oxygen, which is depleted in the warm, stagnant water likely to be left as an ephemeral stream dries down. Rat-tailed maggots (*Eristalis* and *Eristalinus* spp.), aquatic members of the dipteran family Syrphidae, are equally well-suited to ephemeral streams, as they possess long respiratory siphon tubes that assist with breathing atmospheric air and as a group are capable of surviving in low oxygen environments of most ephemeral systems (J. Kennen, pers. comm.). As a ubiquitous taxon with a wide geographic distribution, rat-tailed maggots can be considered as ephemeral indicators for Pacific Northwest streams.
DISCUSSION & CONCLUSIONS

The preceding analysis and compilation of aquatic invertebrate indicator taxa for the assessment of different streamflow classes for Idaho and Washington streams was informed by thoroughly reviewing the scientific literature on temporary vs. perennial stream classes, consulting with regional and national experts, and analyzing biological data sets from stream surveys. These studies confirm that families listed as intermittent indicators are not known to be temporary-obligate, as they may also be found in perennial stream classes. Despite this overlap, a composite of numerous individual indicators and metrics among the different stream classes will serve to provide a robust tool to help differentiate between stream classes for the Streamflow Duration Assessment Method for the Pacific Northwest.

Despite the ubiquity among aquatic macroinvertebrate families globally, regional caveats and local habitat features should be considered for the occurrence and distribution of some indicator taxa. Practitioners should note that, similar to the Oregon indicator study in 2008, not all taxa listed as flow indicators are present in every correlated stream class. Additionally, while many Trichoptera (including Limnephilidae) construct portable cases that can be detected in the stream following development, several caddisfly families are free-living and do not construct cases, and thus leave no trace of previous colonization.

Recommended Indicators
This report identifies macroinvertebrate indicator taxa that show a strong relationship to flow gradients based on their environmental flow requirements (see Appendix A). The recommended taxa for each flow duration category are based on review of scientific literature, contributions from regional and national researchers from different disciplines, and multiple datasets consulted for information on the distribution of indicator families in the Pacific Northwest.

Datasets Consulted


University of Utah Bug Lab data; http://www.cnr.utah.edu/wmc/htm/data.


Regional and National Professional Consultation
To inform the selection of macroinvertebrate indicators, for regional refinements of this list, and for assistance with hydrographic and biological datasets, input was obtained from the following researchers and experts from multiple disciplines:
PACIFIC NORTHWEST FIELD GUIDE

A companion field guide developed for the Pacific Northwest will accompany the Oregon, Washington, and Idaho assessment methods for aid in field identification. Although this field guide is by no means a complete representation of all aquatic macroinvertebrate taxa that inhabit Pacific Northwest streams, all taxa identified in this report as streamflow duration indicators, including macroinvertebrate taxa from Mazzacano and Black (2008) will be incorporated into the field guide along with some other common families likely to be encountered in the Pacific Northwest. Revisions/extensions of the field guide developed in 2008 by Xerces for the Oregon streamflow duration project include: addition of all indicator taxa for Oregon, Washington, and Idaho into one Pacific Northwest field guide, line drawings that represent the general body types of the indicator taxa with descriptions of general morphology, figures of taxa with arrows indicating diagnostic features and descriptions of morphology, scale bars for each taxon to indicate size ranges for the representative families, indicator status of each representative family, and regional distribution for each indicator and/or any ecoregional or habitat considerations. It is anticipated that identification of indicators will be completed to family-level resolution unless the size or immaturity of a specimen limits identification to order.
REFERENCES


**Appendix A. Macroinvertebrate Indicator Taxa List**

### Indicator Families of Streamflow Duration Classes*

#### Idaho & Washington

<table>
<thead>
<tr>
<th><strong>Perennial</strong></th>
<th><strong>Intermittent</strong></th>
<th><strong>Ephemeral</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Adults of:</strong></td>
<td><strong>Larvae/Pupae of:</strong></td>
<td><strong>Larvae/Pupae of:</strong></td>
</tr>
<tr>
<td>Plueroceridae</td>
<td>Physidae&lt;sup&gt;1&lt;/sup&gt; Bladder snails</td>
<td>Culicidae Mosquitoes</td>
</tr>
<tr>
<td><em>Juga</em> spp.</td>
<td>Planorbidae&lt;sup&gt;1&lt;/sup&gt; Ram’s horn snails</td>
<td>Syrphidae Rat-tailed maggots</td>
</tr>
<tr>
<td>Less likely in small, high-gradient streams; absent from Idaho streams</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Margariferidae</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freshwater pearl mussels</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less likely in fishless headwater streams</td>
<td></td>
<td></td>
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<tr>
<td>Unionidae</td>
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<td>Hydrobiidae</td>
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</tr>
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<td>Mud snails</td>
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<td>Ancyliidae</td>
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<td>Freshwater limpets</td>
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<tr>
<td><strong>Larvae/Pupae of:</strong></td>
<td><strong>Nymphs of:</strong></td>
<td><strong>Nymphs/Adults of:</strong></td>
</tr>
<tr>
<td>Philopotamidae</td>
<td>Capniidae Winter stoneflies</td>
<td>Dytiscidae Predaceous diving beetles</td>
</tr>
<tr>
<td>Finger-net caddisflies</td>
<td></td>
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<tr>
<td>Hydropsychidae</td>
<td>Capniidae Winter stoneflies</td>
<td>Hydrophilidae Water scavenger beetles</td>
</tr>
<tr>
<td>Net-spinning caddisflies</td>
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<tr>
<td>Rhyacophilidae</td>
<td>Capniidae Winter stoneflies</td>
<td>Notonectidae Backswimmers</td>
</tr>
<tr>
<td>Free-living caddisflies</td>
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<tr>
<td>Glossosomatidae</td>
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<td></td>
</tr>
<tr>
<td>Saddle case-maker caddisflies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>esp. in clear, cool forested headwater streams</td>
<td></td>
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<tr>
<td><strong>Nymphs of:</strong></td>
<td><strong>Larvae/Nymphs of:</strong></td>
<td></td>
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<tr>
<td>Pteronarcyidae</td>
<td>Lestidae Spread-winged damselflies</td>
<td></td>
</tr>
<tr>
<td>Giant stoneflies</td>
<td>Intermittent indicator only in OR</td>
<td></td>
</tr>
<tr>
<td>Peridae</td>
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<tr>
<td>Golden stoneflies</td>
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<tr>
<td><strong>Larvae of:</strong></td>
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<tr>
<td>Elmidae</td>
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<tr>
<td>Riffle beetles</td>
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<tr>
<td>Psephenidae</td>
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<td></td>
</tr>
<tr>
<td>Water pennies</td>
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</tr>
<tr>
<td>Likely at low abundance</td>
<td></td>
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<tr>
<td><strong>Larvae/Nymphs of:</strong></td>
<td></td>
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<tr>
<td>Gomphidae</td>
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</tr>
<tr>
<td>Clubtail dragonflies</td>
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<td></td>
</tr>
<tr>
<td>Less likely in W, WA streams</td>
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<tr>
<td>Cordulegastridae</td>
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<tr>
<td>Biddies</td>
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<tr>
<td>Calopterygidae</td>
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</tr>
<tr>
<td>Broad-winged damselflies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>esp. in larger, higher order streams</td>
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<td></td>
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<tr>
<td><strong>Larvae of:</strong></td>
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<tr>
<td>Corydalidae</td>
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<tr>
<td>Dobsonflies &amp; Fishflies</td>
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</tr>
<tr>
<td>Likely at low abundance</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Recommended Community Indicator Metrics</strong></td>
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<tr>
<td>Nymphs of ≥4 different families of Ephemeroptera (mayfly)</td>
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<tr>
<td>Greatest taxa diversity</td>
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<td></td>
</tr>
<tr>
<td>High EPT</td>
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<td></td>
</tr>
<tr>
<td>High EPT/OCH</td>
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</table>

*Please note: Taxa in this list are not officially ranked and do not reflect superiority of indicator status. All indicators apply to Idaho, Washington, & Oregon streams; with the exception of Lestidae, which only apply to intermittent streams in Oregon.*

<sup>1</sup>Physidae and Planorbidae families have been observed in ephemeral streams in central Washington and in intermittent streams in Idaho. Due to the contradicting information from regional experts, the designation of these families is therefore conditional upon additional testing in the Pacific Northwest.