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Title: Structural Variations of Headwater Stream Food Webs Along Geophysical Gradients at the HJ Andrews Experimental Forest

Abstract approved:

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Ivan Arismendi

The structure of food webs and how they relate to community stability has been an important debate in ecology. Specifically, predictability of web shape and how it influenced by surrounding landscapes is one of the main goals of such discussions. Headwater streams provide a study template that is of interest to both aquatic and food web ecologists, as headwaters are linked to a myriad of ecosystem services and provide a linear system in which to study the transition of food web structures along natural gradients. This thesis uses network topology from 18 food webs to examine how food webs vary along a headwater stream gradient and how changes in structure relate to geophysical surroundings.

I found that web structure could be strongly associated with both local and landscape scale conditions, including stream slope and basin area. A comparison of structural metrics among the 18 webs show similarities based on basin size and surprisingly were not strongly influenced by geographic proximity. In addition, there were

significant structural differences between food webs located in upstream and downstream locations. Importantly, metrics related to stability, such as connectance, omnivory, and average path length, varied systematically from upstream to downstream, eluding to the idea that downstream communities may be more resilient against disturbances. Results from this study can help ecologists understand how structure relates to function and stability of aquatic ecosystems and could aid in forecasting how these communities may change with alterations to surrounding landscapes.

Structural Variations of Headwater Stream Food Webs Along Geophysical Gradients
at the HJ Andrews Experimental Forest

by

Lauren E. Zatkos

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I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Lauren E. Zatkos, Author

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1. Introduction

The search for repeated patterns in food web structure emerged almost simultaneously with the increased knowledge of natural food web complexity (May 1983; Pimm et al. 1991; Power et al. 2013). In riverine systems, potential connections between surrounding landscapes and stream network characteristics with aquatic communities have been hypothesized and explored through foundational ideas such as the River Continuum Concept (Vannote et al. 1980), habitat templates (Poff and Ward 1990) and patch dynamics (Townsend 1989), as well as the concept of "riverscapes" (Fausch et al. 2002). Though much of this theoretical work has been supported by empirical evidence (Closs and Lake 1994; Cross et al. 2013; Schindler et al. 2015), overarching structural patterns in food webs have remained unidentified (Power and Dietrich 2002). For example, geophysical landscape attributes affecting freshwater systems in the Pacific Northwest including forest canopy composition influence on light dynamics and primary production (Warren et al. 2017) and hydrologic and disturbance regime impacts on valuable species like salmonids (Larson et al. 2004; Penaluna et al. 2015). However, these same large-scale processes also affect entire aquatic communities and influence how species interact (e.g., the food web) (Thompson and Townsend 2005). While attention has been paid to how individual aspects of communities react to geophysical variations, it remains unclear how entire food web structures within a stream network may differ along natural gradients of these large-scale geophysical variables.

The importance of templates (Poff and Ward 1990), or the unique biology, chemistry, and disturbance regime that characterizes habitats, has been demonstrated to affect food web structure within lotic systems in multiple studies (Power 1992; Parker and Huryn 2013), and should be integrated into all attempts to identify food web patterns. Variations in habitat templates can affect the structure of aquatic food webs in numerous ways; for example, the amount of complexity and refugia in a habitat has been found to influence aspects like energy flow and predator-prey dynamics in both marine and freshwater systems (Bellmore et al. 2015; Ziegler et al. 2017). In addition, the role of geomorphic landscape features and riparian vegetation is known to influence both the rate of organic matter processing and consumer populations in lotic ecosystems (Gregory et al. 1991). Shifts in food web composition have also been found with experimentally and naturally varying levels of light and gross primary production (Gregory 1980; Heaston et al. 2018). These habitat template characteristics can result in trickle-up effects to influence predator-prey dynamics within food webs, which can in-turn influence interaction strengths and the feeding mechanisms of species in a stream (Warren et al. 2016; Kaylor and Warren 2017). The influence that these geophysical factors (e.g., geomorphic landscape features, surrounding vegetation, streambed composition) have on aquatic communities, coupled with the steep landscapes and seasonal hydrology that characterize headwater systems, result in unique food webs characterized by frequent disturbance and extreme fluctuation in environmental conditions.

Headwater stream networks in mountainous Mediterranean climates are subjected to major changes in flow and surrounding riverscape across relatively short spatial extents (Johnson et al. 1996; Ward et al. 2019). Because these ecosystems are so dynamic, stabilizing components of food webs may be critical to the resilience of stream food webs in these regions. Understanding the functionality and resiliency of these systems should be considered a priority in aquatic ecology research, as headwaters comprise approximately 79% of river miles in the contiguous U.S. (Colvin et al. 2019), strongly influence downstream water quality, and provide a myriad of ecosystem services (Lowe and Likens 2005). Predictable patterns of hydrology, as well as continuous gradients of stream size, slope, and substrate, may result in patterns of food web structures along headwater networks, with webs in downstream habitats becoming more homogenized where flow is more stable and refugia and habitat complexity increases. Additionally, it may be hypothesized that communities in the smallest streams are characterized by less stability as these habitats are smaller and provide less refugia for aquatic organisms. Certain food web aspects, such as web complexity and omnivory, are believed to increase community stability (De Angelis 1975; Long et al. 2011) and thus, patterns in these features should be of broader interest to ecologists. In particular, high levels of complexity and omnivory may buffer headwaters against major disruptions to the food chain (Warfe et al. 2013; Wootton 2017). To date, it is unclear how these food web attributes, as well as other topological web aspects, change with increasing stream order along a headwater network gradient.

Indeed, there has been a tendency in food web research to disregard or simplify omnivory, with increasing difficulty of capturing such complexity or its irrelevance to web stability often being cited as the main purpose for such omissions (May 1983; Zhao et al. 2019). In early modeling studies, omnivory was not found to increase stability, but rather it was theorized this mechanism could be potentially destabilizing (Melian and Bascompte, 2002). However, omnivory is particularly prevalent in freshwater systems (Thompson et al. 2012) and, contrary to past beliefs, it could increase the stability of food webs (Fagan 1997). In addition, the complexity of web interactions was also once considered to be destabilizing (Gardner and Ashby 1970) though now is attributed to community stability when interaction strengths between the majority of species are relatively low (Emmerson et al. 2004). It has been hypothesized that characteristics such as omnivory and complexity strongly influence food web structure and resiliency to disturbance, and this has been tested in varying ecosystems and specific sites within aquatic networks (Dunne et al 2002*a*, Banerjee et al 2016). There is a lack of empirical evidence that evaluate how these community aspects may shift along and within a large-scale naturally occurring riverine system, and what these shifts mean for community stability.

Network topology analyses of complex ecological food webs have been used to understand the structure and function of marine, terrestrial, and freshwater communities (Poisot and Gravel, 2014). Analyzing connectance food webs (i.e., webs that show all feeding interactions between all species in a community (Sabo et al 2009)) from a topological approach allows for the consideration of all taxa and trophic levels when calculating structural metrics, and can provide a network-wide view that may help researchers quantify relationships between food web attributes (Cohen et al. 2009; Peterson et al. 2013). While this method does not incorporate interaction strengths or energy flows like more commonly utilized energy flow or functional food webs (Paine 1980), topological food web studies allows researchers to explore how the entire community structure may influence the resiliency of a community to disturbance (Sabo et al. 2009).

Here, I used ecological network theory to identify the presence or absence of similarities amongst food web structures along a natural headwater gradient. I quantified a variety of structural aspects of webs found in first- through fifth-order streams within a single watershed and compared these using a non-metric multidimensional scaling analysis to identify any potential structural patterns. I hypothesized that food web shape will be most similar to other web shapes of comparable network location and surrounding landscape within the stream system. In addition, I expect to see a gradient of food web metrics from up-stream to down-stream along the headwater gradient and that stability of communities will range similarly. I investigated the role that omnivory plays in structuring these food webs by modeling the removal of omnivorous species from food webs. I hypothesized that if omnivory impacts the structure of these stream communities then its removal will result in significant structural changes to food webs. My findings will allow ecologists to understand if and how aquatic communities could be forecasted to change with future alterations to landscape. In addition, this will facilitate understanding of the function and structure of food webs and how dynamics of food webs may be predicted to vary along geophysical landscape gradients.

2. Methods

2.1 Study Sites

I conducted this study within the HJ Andrews Experimental Forest (HJ Andrews), Oregon (**Figure 1**). The HJ Andrews was established as an Experimental Forest in 1948 and is a site in the Long-Term Ecological Research (LTER) network. The HJ Andrews Forest is located in the Willamette National Forest in the western Cascade Mountain Range. Forests are primarily dominated by Douglas fir (*Pseudotsuga menziesii*), red cedar (*Thuja plicata*), and western hemlock (*Tsuga heterophylla*). Riparian vegetation is characterized by alders (*Alnus rubra*), salmonberry (*Rubus spectabilis*), and vine maple (*Acer ciercinatum*). Portions of these forests were logged in the 1960's-70's while much of the area is old-growth temperate rainforest with no major anthropogenic disturbances post-logging. The HJ Andrews watershed is Lookout Creek, a fifth-order stream that flows into the Blue River Reservoir. No major hydrologic disturbances have occurred in this watershed since a major flooding event in 1996 (Johnson et al. 1996).

The HJ Andrews is located within a primarily rain and snow-dominated Mediterranean ecosystem. Streams in this watershed range from one to firth order and receive an average of 213 cm of rainfall annually. Stream temperatures typically range from 8 – 16°C. Aquatic vertebrates dominating lower Lookout Creek watershed include fishes such as cutthroat (*Oncorhynchus clarkii clarkii*) and rainbow trout (*O. mykiss*), sculpins (*Cottus spp.*), and dace (*Rhinichthys spp.*), and amphibians including the coastal giant salamander (*Dicamptodon tenebrosus*) and tailed frog (*Ascaphus truei*). Higher in the watershed many of these vertebrates are absent, and many first through third-order streams are inhabited by only *O. clarkii* and *D. tenebrosus*, only *D. tenebrosus*, or neither predator due to lack of habitat or physical barrier to fish movement.

2.2 Datasets and Sampling

I used information from both previously conducted surveys as well as my own survey data to compile the most complete food webs possible containing all detectable aquatic invertebrates and vertebrates (**Table 1**). This effort resulted in a total of 18 constructed stream food webs. More information on additional studies conducted using these data or sites can be found on the HJ Andrews webpage (https://andrewsforest.oregonstate.edu/). Eight of these survey sites used here were located in small (<110 ha) basin areas, eight in medium (300-800 ha) basin areas, and two in large (1,500-6,500 ha) basin areas. All sites were collectively surveyed via both Surber sampling and backpack electrofishing to detect the presence and/or absence of aquatic organisms during separate sampling periods in summers between 2001- 2018. Macroinvertebrates collected via Surber sampling were immediately preserved in ethanol, identified in a laboratory, and abundances and densities were recorded to the highest possible taxonomic resolution. Vertebrates collected during backpack electrofishing were identified in the field and abundances were recorded at species level (**Table 1**).

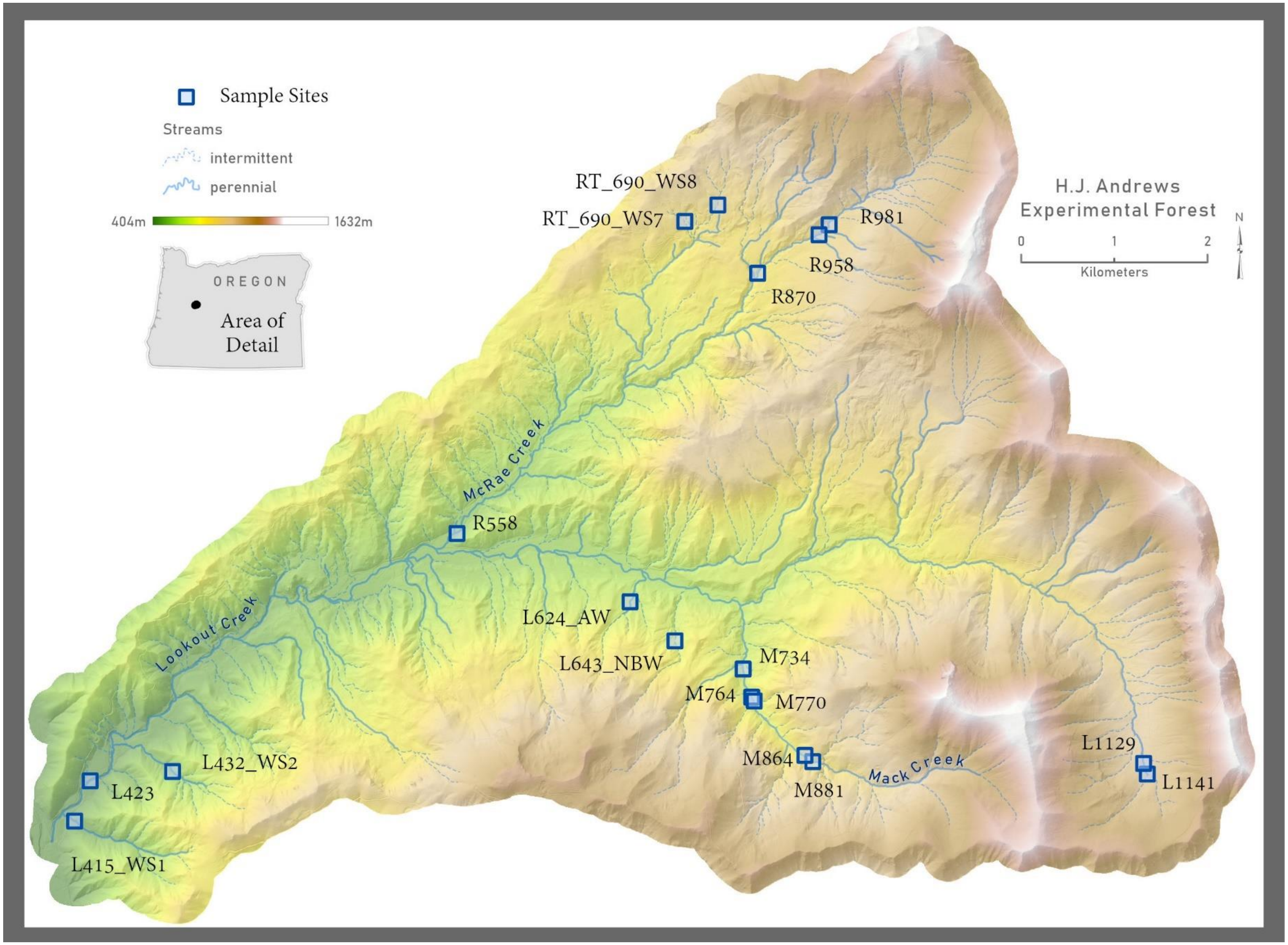


Figure 1. Map of Lookout Creek stream network and corresponding location of study sites that were used to create 18 food webs.

Table 1. Overall description of available data and study sites at the HJ Andrews Experimental Forest, Oregon.

Location	Site ID	Site Name	Stream Order	Dates Sampled*	Source	Season(s) Sampled	Data †
N 44.21086, W -122.11386	L1141	Lookout Fishless Section	1	2018	LTER Stream Team/This study	Summer	M,A,F
N 44.21188, W -122.11435	L1129	Lookout Fish Section	2	2018	LTER Stream Team/This study	Summer	M,A,F
N 44.21121, W -122.25596	L423	Lower Lookout	5	2011 and 2016	U.S. Geological Survey[1]	Summer	M,A,F
N 44.26422, W -122.15586	R981	McRae Fishless Section	2	2018	LTER Stream Team/This study	Summer	M,A,F
N 44.26326, W -122.15724	R958	McRae Fish Section	2	2018	LTER Stream Team/This study	Summer	M,A,F
N 44.25959, W -122.16555	R870	McRae NEON	3	2017	NEON dataset[2]	Summer-Fall	M,A*,F*
N 44.23476, W -122.20634	R558	McRae SCALER	4	2014 and 2016	LTER Stream Team/This study	Summer	M,A,F
N 44.21238, W -122.15882	M881	Mack Fishless Section	3	2018	LTER Stream Team/This study	Summer	M,A,F
N 44.21300, W -122.15985	M864	Mack Fish Section	3	2018	LTER Stream Team/This study	Summer	M,A,F
N 44.21868, W -122.16693	M770	Mack Old-Growth	3	2001	Johnson dataset[3]	Summer	M,A*,F*
N 44.22140, W -122.16805	M764	Mack Clear Cut	3	2001	Johnson dataset[3]	Summer	M,A*,F*
N 44.21836, W -122.16673	M734	Mack Long-Term	3	2018	This study	Summer	M,A*,F*
N 44.26467, W -122.17528	RT_690_WS7	Watershed 7	1	2003-04, 2018	Frady, 2006[4]	4 Seasons (Summer)	M,A,F
N 44.26623, W -122.17081	RT_690_WS8	Watershed 8	1	2003-04, 2018	Frady, 2006[4]	4 Seasons (Summer)	M,A,F
N 44.22419, W -122.17717	L643_NBW	New Belgium Watershed	1	2003-04, 2018	Frady, 2006[4]	4 Seasons (Summer)	M,A,F
N 44.22800, W -122.18316	L624_AW	Anderson Watershed	1	2003-04, 2018	Frady, 2006[4]	4 Seasons (Summer)	M,A,F
N 44.20734, W-122.25809	L415_WS1	Watershed 1	3	2003-04, 2018	Frady, 2006[4]	4 Seasons (Summer)	M,A,F
N 44.21204, W-122.24488	L432_WS2	Watershed 2	2	2003-04, 2018	Frady, 2006[4]	4 Seasons (Summer)	M,A,F

* Dates sampled separated by ","sampling conducted by different investigators at different times. † Data include macroinvertebrate (M), amphibian (A), and fish (F). Abbreviations denoted by "*"data was not collected, but inferred through communications and additional surveys. Underlined text shows that only certain data was used if dataset included multiple sampling years or seasons. [1]U.S. Geological Survey, 2016, Survey of Lookout Creek Vertebrates. Unpublished raw data. [2]National Ecological Observatory Network, 2019. Data Products: MCRA.DP1. Provisional data downloaded from http://data.neonscience.org. Battelle, Boulder, CO, USA. [3]Johnson, S. & Frady, C., 2001. Macroinvertebrates of stream reaches in coniferous and deciduous forests. Unpublished raw data. [4]Frady, C., Johnson, S. & Li, J. (2006). Stream Macroinvertebrate Community Responses as Legacies of Forest Harvest at the H.J. Andrews Experimental Forest, Oregon, 13.

2.3 Food Web Construction

The biological community data used in my analysis included presence/absence of all invertebrates and vertebrates at each stream site (see **Appendix A** for taxa list). Trophic interactions between taxa were determined by previously conducted studies including diet analyses (laboratory and field observations), and isotopic analysis. No information for the predatory dragonfly nymph *Octogomphus spp.* (club-tailed dragonfly) was available, so 80 individuals were collected to conducte a dietary analysis to include this taxon in the webs. I used the distribute-parents-among-children method recommended by Cuffney *et al.* (2007) to standardize all macroinvertebrate datasets that had differing taxonomic resolutions as a result of the various identification methods employed by multiple labs.

I used package Cheddar (Hudson 2012) in program R (version 0.1-633) to construct food webs at each site using survey data of taxa presence/absence within each community and the compiled list of trophic interactions. Cheddar allows users to visualize and analyze ecological food webs by plotting interaction properties, calculating structural metrics (**Table 2**). In addition, the function 'WebBuilder' within Cheddar was used to create additional trophic links extrapolating from a list of minimum resource and minimum consumer methods of all taxa (Gray et al. 2015). These methods were collected from a literature review and specify the minimum taxonomic resolution at which a taxa has been observed to be either a resource (prey) or consumer (predator) of other taxa.

2.4 Data Analysis

I used 16 structural network metrics (**Table 2**) for each food web to characterize and contrast among food webs and along geophysical gradients. These 16 food web metrics represent many aspects of the structure of each food web as well as the interactions between taxa and trophic levels. Eight geophysical variables were extracted using ArcGIS (ESRI) and datasets available on the HJ Andrews Open Data Hub (https://data-osugisci.opendata.arcgis.com/), including elevation (m), drainage area (km^2), network density, average canopy cover per watershed, sinuosity, stream slope (%), and Euclidean and stream distances (m). These variables were compared alongside food web metrics to identify any associations. We calculated Euclidean and stream distances (m) among sites to account for similarities contributed to spatial proximity. We created resemblance distance matrixes to examine similarities among food web structures, geographic location, and geophysical aspects. A non-metric multidimensional scaling technique (nMDS) was used to visualize potential clustering of food web structures. A cluster analysis (single link method) was conducted using geographic proximity and the resulting nMDS location points to test if location between sites could explain variation in food web structural similarities. In addition, we performed Mantel tests using Primer7 software (Clarke and Gorley, 2015) to examine associations between geophysical gradients and food web metrics as well as with proximity.

Food web structures were grouped based on basin area size (small, medium, large) and an analysis of similarities (ANOSIM) was conducted using the resemblance matrix to evaluate potential differences between groups (ANOSIM conducted in Primer7 software; Clarke and Gorley, 2015). In addition, we performed Pearson correlation analyses between food web structure and the geophysical variables to analyze structural metric relationships with the surrounding landscape (**Appendix B**). Student's *t* and, when normality or equal variance assumptions were not met, Mann-Whitney *U* tests were performed to compare metric values between up- and downstream sites within the Lookout Creek basin. Medium and large basin area sites were grouped into one category so sample sizes between groups (small and medium/large) were comparable (n=8 per grouping).

Food webs were artificially manipulated using Cheddar to extract omnivorous species (species that feed from more than one trophic level) from each system and selected metrics were recalculated. Metrics related to stability (connectance, linkage density, average path length, prey:predator ratios, and number of links) were chosen for this omnivory-removal modeling as the influences of these structural aspects are the most commonly studied (Bengtsson 1994, Dunne et al. 2002b, Neutel et al. 2007). Manipulated food webs without omnivory were compared with original food webs (with omnivory) to identify changes in food web structure.

3. Results

There was considerable variation between structural metrics measured within the 18 food webs. The food webs range in size from 49 to 84 taxa (**Appendix C**); had linkage densities ranging from 7.8 – 14.7 and connectance (*Co*) values of 0.13 – 0.20. The fraction of the webs made up of omnivorous taxa (*O*) ranged from 0.34 – 0.57, and webs had average path lengths (APL) of 1.69. When all structural metrics were considered to create a nMDS plot, the resulting ordination space showed clustering of structures by small (<100 ha), medium (300-800 ha), and large (1,500-6,500 ha) basin area categories along the x-axis (**Figure 2).** The resulting R values of the ANOSIM (**Table 3**) further supported that food web structures from sites with small drainage areas are significantly different from webs located in medium (R statistic 0.291, pseudo p-value = 0.001) and large drainage areas (R statistic 0.828, pseudo p-value = 0.0022).

Table 2. Structural food web metrics and definitions to be used in the analysis.

Structural Food Web Metric	Definition
Node (S)[1]	Taxa, or taxa richness.
Link (L)[1]	Feeding interaction between taxa.
Linkage Density (L/S)[1]	Average number of links per node.
Connectance (L/S^2)[1]	Proportion of links that actually occur in a community compared to the maximum number of theoretical links.
Characteristic Path Length[2]	Average number of links necessary for energy, information, or an effect to propagate the network.
Fraction of Omnivory[3]	Proportion of taxa that feeds from ≥2 trophic levels, taxa that have non-integer trophic level.
Fraction Top-Level Nodes[4]	Proportion of taxa in the highest trophic level.
Fraction of Intermediate Nodes[4]	Proportion of taxa in middle trophic level(s).
Fraction of Basal Nodes[4]	Proportion of taxa in the bottom trophic level (basal species; primary producers).
Fraction of Non-Top-Level Nodes[4]	Proportion of all taxa not in the highest trophic level.
Fraction of Cannibalism[5]	Proportion of taxa that consume intraspecifics.
Sum of Diet Gaps[6]	Total number of gaps in each taxa's diet that cannot be made graphically continuous because of restrictions presented by other taxa diets. A low value of this metric indicates a network with high intervality.
Sum of Consumer Diet Gaps[7]	Total number of gaps in each consumer's diet when potential resource taxa are aligned continuously along one axis.
Mean Maximum Trophic Similarity[8]	Proportion of predator and prey taxa two nodes have in common. The larger this metric value is, the more similar interactions two nodes may experience. Mean maximum trophic similarity is the average value for all nodes in the entire network.
Maximum Trophic Position[9]	Trophic position of top-level taxa in food web.
Prey:Predator Ratio[10]	Ratio of prey to predator taxa for whole community.

[1]Delmas et al, 2018, *Biol Rev*, 94, 16-36. [2]Williams et al, 2002, *PNAS*, 99(20), 12913-12916. [3]Thompson et al, 2007, *Ecology*, 88(3), 612-617. [4]Hudson, 2018, *Methods in Ecology and Evolution*, 4(1), 99--104. [5]Woodward et al, 2002, *Journal of Animal Ecology*, 71, 1063-1074. [6]Stouffer et al, 2006, *Proceedings of the National Academy of Sciences*, 103(50), 19015-19020. [7]Zook et al, 2011, *Journal of Theoretical Biology*, 271(1), 106-113. [8]Williams et al, 2000, *N ature*, 404, 180-183. [9]Sabo et al, 2009, *Annals of the New York Academy of Sciences*, 1162(1), 187-220. [10]Abrams et al, 2000, *Trends in Ecology & Evolution*, 15(8), 337-341.

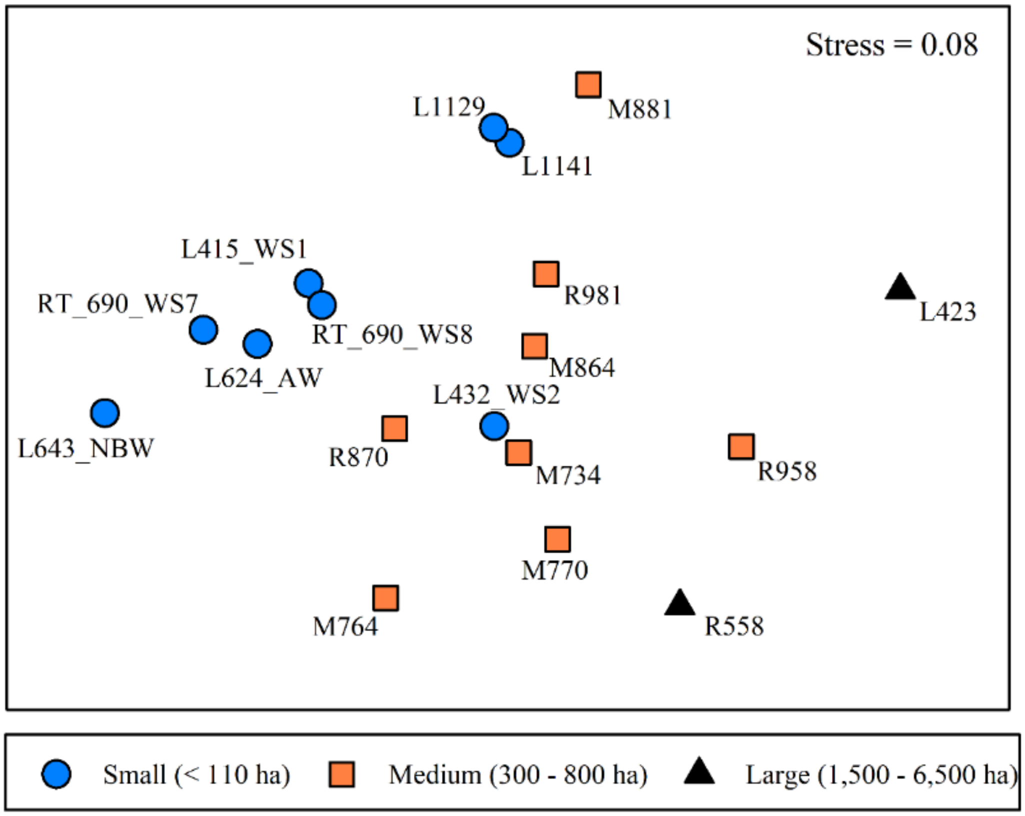


Figure 2. nMDS ordination of all food webs sampled within the headwater stream network at the HJ Andrews. Food web sites were classified by drainage basin size (ha²). Stress = 0.08.

Table 3. ANOSIM contrasting food web structure among basin size groups (small, medium, and large basin area). Sample statistic R = 0.37, significance level of sample statistic = 0.1%. Statistically significant values in bold at 0.05.

Groups	R Statistic	pseudo-P value
Small vs Large	0.828	**0.022**
Small vs Medium	0.291	**0.010**
Medium vs Large	0.250	0.178

Statistically significant differences in the structural composition of these small drainage area webs compared to webs from medium/large drainage areas were found in seven metrics (**Figure 3; Table 4**). Specifically, t-student and Mann-Whitney analyses demonstrated that predator:prey ratios (p-value = 0.023), APL (p-value = 0.0005), linkage density (p-value = >0.0005), *Co* (p-value = 0.0254) and fraction of middle (p-value = 0.026) and top-level nodes (p-value = 0.006) were statistically significantly different between small and medium/large basin area groups. In the case of *O*, the differences were suggestive (p-value = 0.06). Though these metric values ranged between sites in each basin category, generally *O*, *Co*, the fraction of middle nodes, and linkage density were significantly reduced in food webs located in streams with smaller basin areas (**Fig. 3a, 3c, 3e, 3g**). Prey:predator ratios, APL, and the fraction of top-level nodes were significantly higher in webs from smaller basin areas (**Fig. 3b, 3d, 3f**).

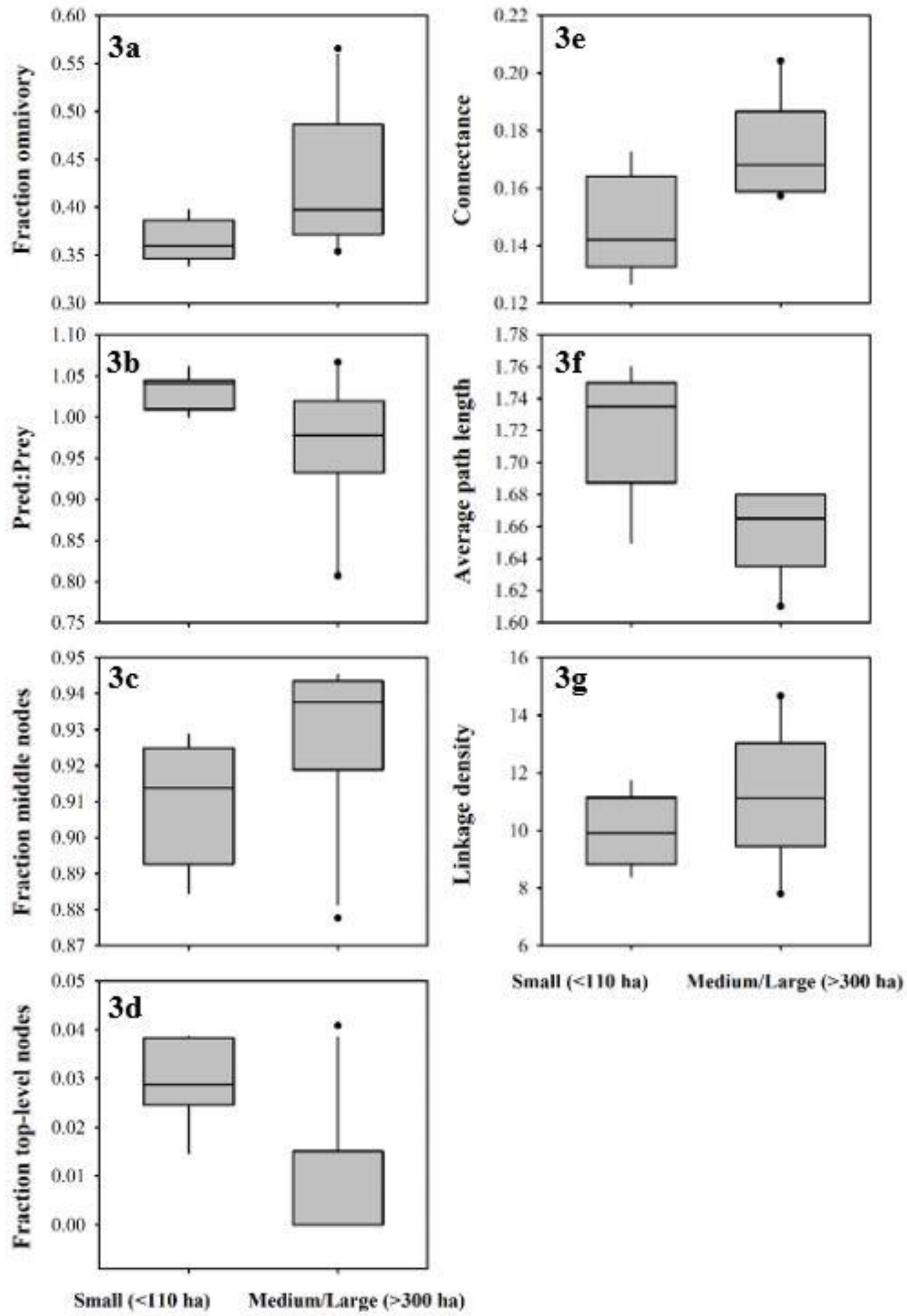


Figure 3. Box plots of differences between structural metric values of food webs located in small (<110 ha) basin areas and medium/large (300-800 and 1,500-6,500 ha) basin areas. Fraction *O* (p-value = 0.06), Predator:prey ratio (p-value = 0.023), fraction of middle nodes (p-value = 0.026), fraction top-level nodes (p-value = 0.006), *Co* (p-value = 0.025), APL (p-value < 0.001), and linkage density (p-value < 0.001).

Table 4. Results of Student t-test metric values comparing food web metrics between basin size groups. When normality or equal variances failed, Mann-Whitney Rank Sum Test was used. Basin size categories included small basins (draining <110 ha; n = 8) and medium/large basins (300-6,500 ha; n = 10). Values in bold and denoted by * are statistically significant at alpha = 0.05.

Food Web Metric	Mann-Whitney U statistic	t-test statistic	p-value
Max trophic position	21.5		0.109
Prey:Predator ratio	14		**0.023***
Number of nodes		-0.666	0.515
Number of links		0.6	0.55
Fraction omnivores		2.438	0.06
Fraction bottom nodes	31		0.449
Fraction middle nodes	14.5		**0.026***
Fraction top-level nodes	9		**0.006***
Fraction non-top level nodes	9		**0.006***
Fraction cannibalistic		-1.005	0.33
APL		-4.306	**<0.001***
Linkage density		1.524	**0.00***
Co		3.234	**0.025***
Sum diet gaps		0.325	0.749
Sum consumer gaps		-0.12	0.906
Mean max trophic similarity		-0.577	0.572

Similarly, medium basin areas were structurally dissimilar to those found in streams with large basin areas (R statistic 0.25, pseudo p-value = 0.0178), though this difference was based on a relatively small sample of large basin area sites (n = 2).

We tested the hypothesis of geographic proximity as an explanation for differences in web structures and found there is no statistical evidence to support this hypothesis; results of the Mantel test showed that neither Euclidean nor stream distance among sites explained variation in structural composition of food webs (**Table 5**). Similarly, idiosyncratic grouping of webs in the cluster analysis revealed proximity did not explain structural dissimilarities (**Appendix D**).

Table 5. Mantel Test results of comparisons between matrices of Euclidean distance, stream distance, geophysical variables, and food web distance distances. A total of 999,999 permutations were run for each comparison. Values in bold and denoted by * are statistically significant.

Comparison	Spearman's rho	pseudo-P value
Food web distance x Euclidean distance	0.018	0.410
Food web distance x stream distance	-0.069	0.739
Food web distance x geophysical distance	0.16	0.104
Geophysical distance x Euclidean distance	0.511	**<0.001***
Geophysical distance x stream distance	0.379	**<0.001***
Stream distance x Euclidean distance	0.902	**<0.001***

Additionally, we tested the hypothesis that geophysical variables influence food web structure by testing associations of geophysical factors against food web location within the nMDS. The x-axis score of the nMDS showed a strong association with only gradient and basin area (**Figure 4**; **Table 6**), while no associations were found between y-axis position and the geophysical variables.

Statistically significant associations were found between stream slope and four food web structural metrics (*Co*, APL, *O*, and maxTP), and between basin area and three structural metrics (*Co*, APL, *O*; **Figure 5; Appendix E**). Positive associations existed between *O* and basin area (Pearson correlation coefficient r = 0.495, p-value = 0.0367; **Fig. 5g**), *Co* and basin area (r = 0.51, p-value = 0.0305; **Fig. 5e**), and APL and gradient (r = 0.703, p-value = 0.0012; **Fig. 5b**). Negative associations were found between APL and basin area (r = -0.519, p-value = 0.0274; **Fig. 5f**), maximum trophic position (maxTP) and gradient (r = -0.515, p-value = 0.0286; **Fig. 5d**), *O* and gradient (r = -0.593, p-value = 0.0095; **Fig.5c**), and *Co* and gradient (r = -0.768, p-value = 0.0002; **Fig. 5a**).

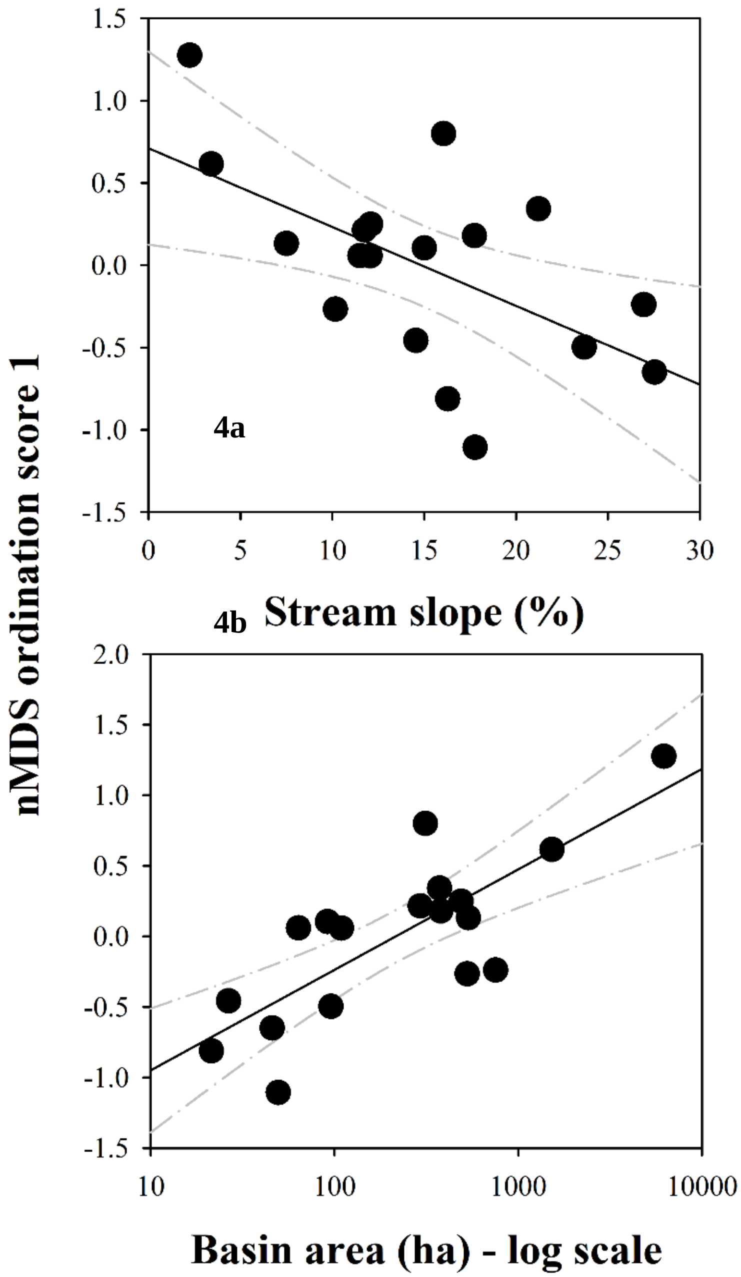


Figure 4. Scatter plots and linear regression analysis of all food webs nMDS score one (i.e. the locations of webs along the x-axis within the nMDS) and two geophysical variables found to be significantly correlated with web structures; **4a**) stream gradient (p-value = 0.005) and **4b**) log of basin area (ha) (p-value = 0.004). Dashed lines represent a 95% confidence interval.

Table 6. Correlation analysis between nMDS scores representing the structure of food webs and geophysical variables. Values in bold and denoted by * are statistically significant.

Geophysical Variable	Test Statistic and p-value	y-coordinate	x-coordinate
Elevation (m)	Spearman rho	0.393	0.087
	p-value	0.107	0.730
Basin Area (log)	Spearman rho	-0.036	0.638
	p-value	0.889	**0.004***
Network Density	Spearman rho	-0.292	0.071
	p-value	0.239	0.781
Average Canopy Cover (%)	Spearman rho	-0.157	-0.039
	p-value	0.533	0.877
Sinuosity	Spearman rho	0.016	-0.035
	p-value	0.950	-0.889
Gradient (%)	Spearman rho	0.289	-0.158
	p-value	0.245	**0.012***

As omnivory is known to promote community resiliency to disturbances, understanding variation in the prevalence of this feeding mechanism provides insights into how stable stream food webs may be. There were strong associations between the proportion of omnivorous taxa and food web structural metrics (**Figure 6; Appendix F**). A positive association was found between *O* and maxTP (r = 0.718, p-value = 0.001; **Fig. 6d**), number of links (r = 0.506, p-value = 0.032; **Fig. 6f**), linkage density (r = 0.707, p-value = 0.001; **Fig. 6b**), and *Co* (r = 0.763, p-value < 0.001; **Fig. 6a**). Conversely, negative associations were found between *O* and to predator:prey ratios (r = -0.654, p-value = 0.003; **Fig. 6e**) and APL (r = 0.718, p-value = 0.001; **Fig. 6c**).

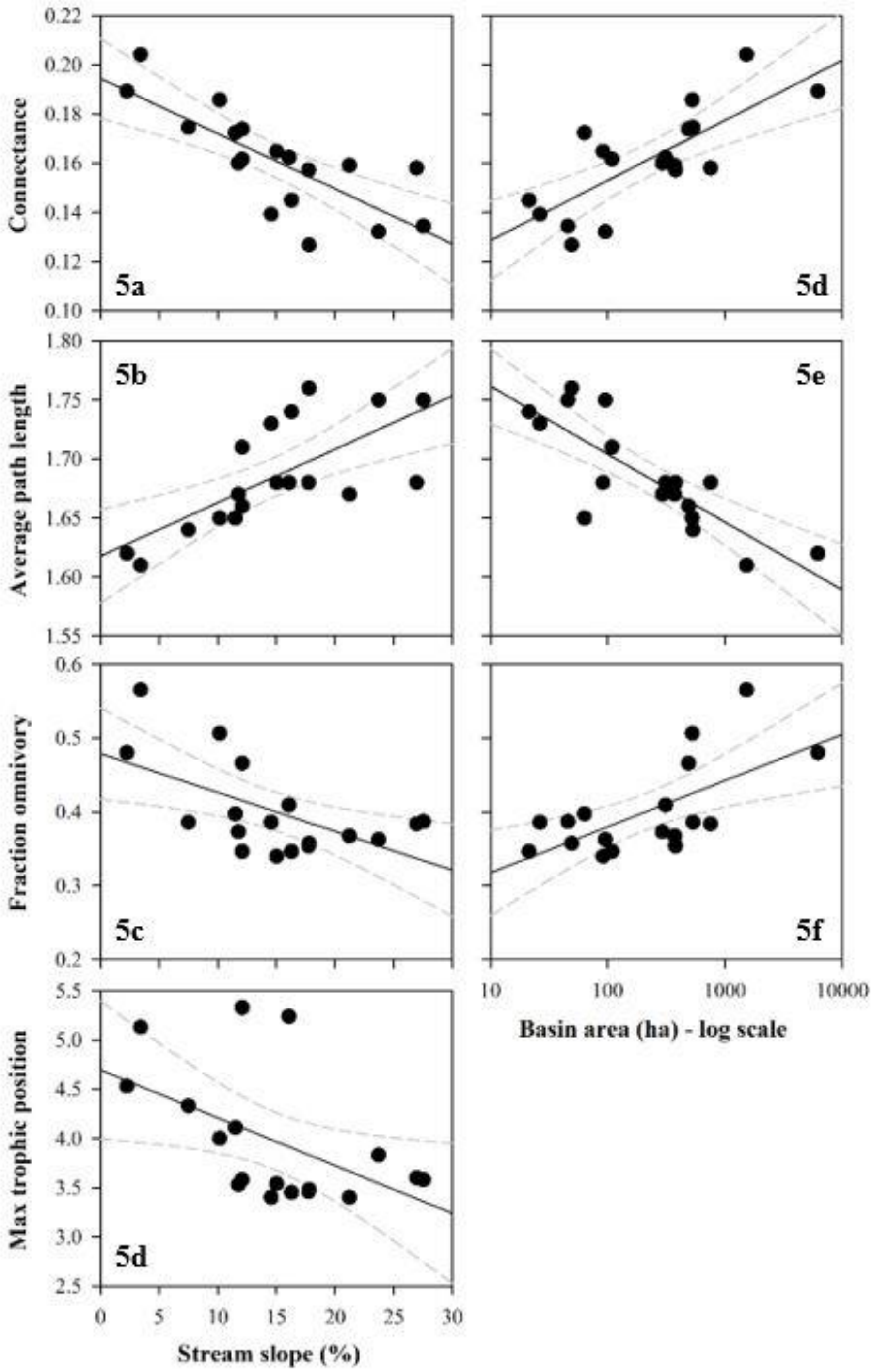


Figure 5. Scatter plots and linear regression analysis of the structural metrics found to be significantly correlated with percentage stream slope (**5a-d**) and drainage area (ha²) (**5e-g**). Dashed lines represent a 95% confidence interval.

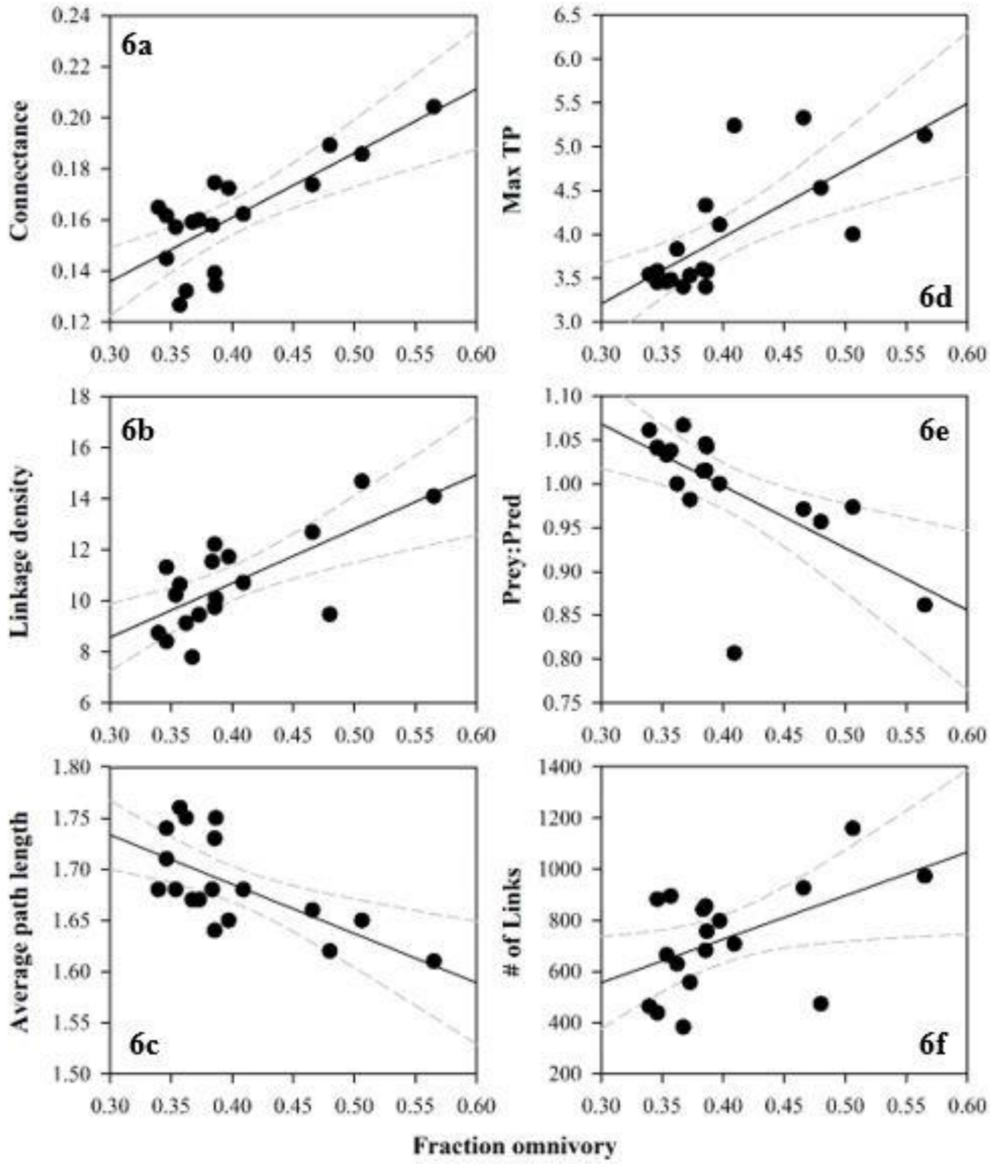


Figure 6. Scatter plot and regression analysis of the six structural metrics found to be strongly correlated with fraction of *O* in each food web. Positive relationships were found between *Co* (**Fig. 6a**), linkage density (**Fig. 6b**), maxTP (**Fig. 6d**), and number of links (**Fig. 6f**) and *O*. Negative relationships were found between APL (**Fig. 6c**) and predator:prey ratios (**Fig. 6e**) and *O*. Dashed lines represent a 95% confidence interval.

When all food webs were manipulated to remove all omnivorous taxa, structural food web metrics significantly varied (**Figure 7**). Clear declines were seen in metrics associated with community stability. Specifically, *Co*, linkage density, predator:prey ratios, and the number of links per web decreased significantly after omnivorous taxa were removed (p-values for all metrics < 0.001). APL was the only metric that significantly increased after omnivory was removed (p-value < 0.001).

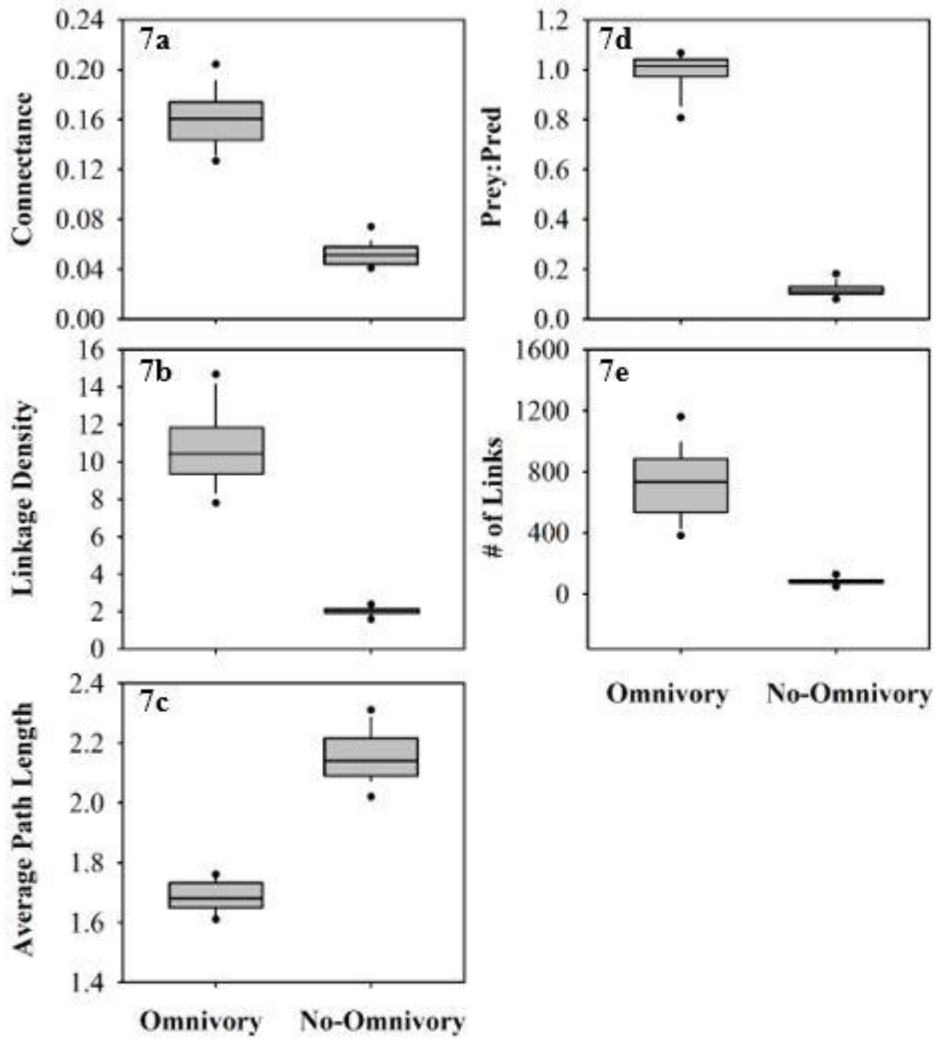


Figure 7. Differences in selected food web structural metrics modeled with and without omnivory. The values of *Co* (**Fig. 7a**), linkage density (**Fig. 7b**), predator:prey ratios (**Fig. 7d**), and the number of links per web (**Fig. 7e**) all decreased significantly when omnivory was removed; APL of modeled no-omnivory webs increased significantly (**Fig. 7c**). All p-values < 0.001.

4. Discussion

The findings of this study support the idea that food web structures in headwater streams could be predictable along geophysical gradients. Basin size and stream slope are strongly associated with the structural metrics of food webs that we investigated, showing that both local and large-scale geophysical attributes can influence aquatic food webs. Importantly, structural metrics directly associated to food web stability show lower values at first- and second-order streams compared to larger order streams. These potential differences in stability may be related to different hydrological regimes and diversity of habitats and refugia for aquatic organisms. In addition, omnivory is consistently prevalent in these stream communities and may play an integral part in shaping food webs. Structural differences between upstream and downstream food webs have been found in other systems (Power and Dietrich 2002; Rosi-Marshall and Wallace 2002), and the importance of omnivory within aquatic ecosystems has been agreed upon by recent empirical evidence (Thompson et al. 2007; Vermaat et al. 2009) despite former theoretical belief. Past modeling using linear feeding chains containing 3-4 species led to theoretical conclusions that increased complexity from omnivory destabilized food webs (Pimm and Lawton 1977). It has since been recognized that simple linear models do not accurately capture food web dynamics, and studies of empirical communities have shown that omnivory is not only prevalent, but potentially stabilizing (Kratina et al. 2012).

Surprisingly, geographic proximity and food web structure are not strongly associated. This is contrary to the belief that highly connected linear habitats, like riverine systems, are subjected to similar conditions and share features such as food web similarities based on proximity (Grant et al. 2007; Peterson et al. 2013). The findings from this study also support the River Continuum Concept (RCC) and the idea of "riverscapes" in that geophysical gradients along a watershed play significant roles in structuring stream food webs, rather than geographic proximity. This is further supported by the differences in structural metric values I found between webs located in small basin areas (up-stream) compared to metric values of webs in medium/large basin areas (down-stream). Results from this study agree with up-stream and down-stream differences in food webs reported in other studies that investigated other geophysical factors. For example, differences in the base of food chains were found to be determined by stream slope in a study of 16 streams in Bristol Bay, Alaska (Smits et al. 2015), and variations in average path length (APL) and energy assimilation were found with habitat template heterogeneity along the Kanawha River basin in West Virginia and Virginia (Thoms et al. 2017). It could be possible that these up-stream and down-stream differences in food web structure may be generalized in lotic ecosystems.

I observe differences in food web structure between the upper and lower extents of our study system consistently using multiple metrics. Predator-prey ratios, while not investigated along landscape gradients, have been found to vary considerably between open and margin habitats within pond ecosystems (Warren 1989), despite theoretical belief that these ratios should remain relatively constant (Cohen 1978). Because most literature focuses on omnivory, connectance (*Co*), and APL, our following discussion will focus on these metrics. Studies of these metrics have also found differences based on habitat variation and geophysical gradients. *Co* and its association with ecosystem size and primary production types have been analyzed by numerous studies (Warren 1989; Dunne et al. 2002; Thompson et al. 2005*a*, Neutel et al. 2007). Though very few studies have investigated how *Co* is associated with geophysical gradients, one study shows that habitat variability (i.e., stream depth, width, and flow) may play a role (Thompson et al. 2005*b*). APL has been related to community stability (Pimm 2002; Sabo et al.

2009) and is an important structural food web metric that has been a focus in food web ecology. Positive relationships are seen between complex habitat/refugia and APL, *O,* and consumer dynamics in lake food webs in a modeled experiment fitted with empirical data (Ziegler et al. 2017). Sabo (2010) reported negative associations between flow variation and APL, and positive associations between basin size and APL based on data from 36 North American rivers. While the findings here support Sabo's conclusions that hydrology impacts food web shape and stability, in contrast, I show APL decreases with increasing basin size. These apparent discrepancies could be explained by variations in surrounding landscape and basin-specific features of study sites. For example, the 36 rivers in the larger analysis were located across the North American continent and the current study focused on a single watershed. It is possible that idiosyncrasies between APL of these 36 communities resulted from widely varying attributes of the unrelated watersheds, whereas the 18 webs surveyed in this study experience a continuous gradient of attributes within a shared landscape and region. These studies can help explain why there are differences in food web structures between up- and down-stream sites, as they support the idea that both abiotic and biotic variations are important in shaping aquatic food webs. While habitat templates are believed to influence some of these metrics, relationships between other food web metrics and the surrounding landscape have yet to be thoroughly investigated.

Of particular interest is that *Co, O,* and APL vary with stream slope and watershed size (**Figure 8**), as these aspects of food web structure have been related to community resilience against disturbances - hereafter called stability (Dunne et al. 2002*b*). I show that these structural metrics are strongly associated with both local and landscape-level geophysical factors including gradient of stream slope (*Co*, *O*, APL, and maxTP) and basin area (*Co*, *O*, and APL). The relationships that *Co*, *O*, and APL have with stream slope are inverse to those they have with basin area, meaning food webs in smaller, steeper streams have lower *Co* and *O* while webs in larger, more gradual streams exhibit higher values. Similarly, as longer APLs are observed in smaller, steeper streams, they shorten as stream size increases and slope decreases.

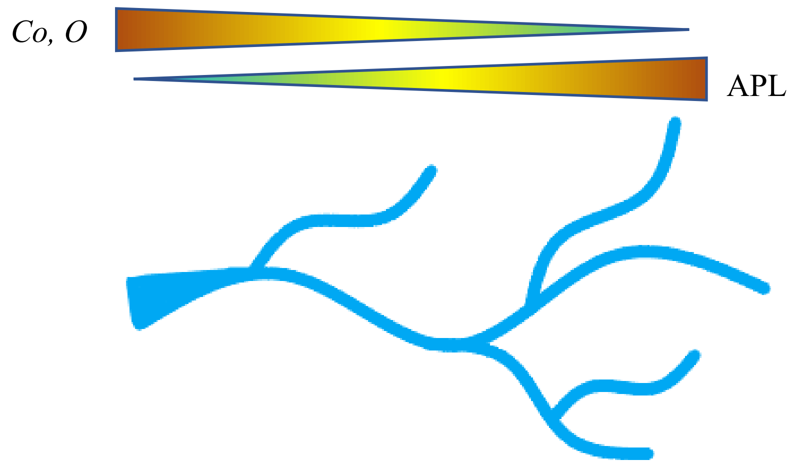


Figure 8. Summary figure of how metrics scaled along headwater stream system with graidents of stream slope and basin area. As stream slope increased (generally) upstream, APLs were longer while values of *Co* and *O* were smaller when compared with downstream sites. Downstream as stream slope (generally) decreased and basin areas were larger, APLs were shorter and values of *Co* and *O* were larger relative to upstream sites.

This lends to the idea that webs seem to be more stable downstream, as *Co* and *O* have been found to be positively related to stability (Fagan 1997; Belgrano et al. 2005; Gilbert 2009) and APL has been shown to be negatively related to stability (Pimm 1977; Long et al. 2011). Especially surprising is the lower values of *Co* seen in upstream communities, regardless of the largest diversity of taxa being found there (an average of 69 taxa identified in small basin sites, 67 taxa in medium basin sites, and 60 taxa in large basin sites). A possible explanation for this lies in the spatiotemporal variations experienced throughout headwaters; specifically changes in flow and disturbance throughout the system (Lake 2000; Sabo et al. 2010). I suggest that in smaller, steeper streams (i.e. first- and second-order), there may be a lower threshold of achievable stability in these communities and food webs, constrained by a lack of complex habitat for organisms to seek refugia in during more frequent and severe disturbances. While ecological theory supports this idea (Pimm et al. 1977; McCann et al. 1997; Kratina et al. 2012), empirical and modeling studies show contrasting results. While *Co* is reported to be negatively associated with ecosystem stability in modeled 3- and 4-species food webs (Monteiro et al. 2016), species extinction modeling of 16 highly resolved empirical food webs found *Co* to be positively related to stability (Dunne et al. 2002*b*). The dynamic-stability hypothesis asserts that energy has less distance to travel through a food web with shorter APLs, allowing these webs to recover quickly following a disturbance (Pimm and Lawton 1977; Carpenter et al. 1992), and supports my hypothesis that downstream sites with smaller APLs are more stable. The increased prevalence of *O* in an ecosystem is found to stabilize communities by increasing the number of weak interactions between species and buffering systems during and post-disturbance (Rosi-Marshall et al. 2002; Pillai et al. 2011; Wootton 2017).

Biological differences between up-stream and down-stream in my study stream network may also help explain the lower levels of stability in small basin areas. While streams lower in the network support populations of crayfish (*Pacifastacus leniusculus*), sculpins (*Beldingii spp.*), rainbow trout (*Oncorhynchus mykiss*), and dace (*Rhinicthys spp.*), smaller-order lack this predator diversity. Whereas a portion of small-order streams support abundant cutthroat trout (*O. clarkii*) and coastal giant salamander (*Dicamptodon tenebrosus*) populations, the other portion of first-order streams are inhabited by neither of these vertebrate predators due to their small size or the presence of a physical stream barrier to fish. Even some second- or third-order streams contain the coastal giant salamander as the sole vertebrate predator, due to barriers to fish movement existing downstream of these reaches. This may have implications for food web structuring, as increased diversity of intermediate and top-level predators has been shown to decrease interaction strengths within food webs, thus stabilizing communities (Finke and Denno 2004; Jonsson et al. 2007; Woodward et al. 2008). As small streams generally do not have the habitat or resource supply to support large diversities of large-bodied generalist predators, these webs may be expected to be less complex and therefore less resilient to disturbances when compared to larger streams with additional omnivorous, predatory taxa.

Overall values of *O* throughout my study system are high, with lowest levels seen upstream and increasing downstream. *O* is prevalent across all ecosystem types and be especially abundant in aquatic food webs (Thompson et al. 2012). While evidence exists that *O* can enhance community stability (Gellner et al. 2012; Wootton 2017) and influences predator-prey relations (Polis and Strong 1996; Woodward et al. 2002), little focus has been paid to how it affects food web structure or changes along geophysical gradients. The strong associations between *O* and other food web structural metrics found here supports the hypothesis that *O* plays a major role in structuring the headwater webs. Similar associations between *O* and APL are reported in freshwater planktonic food webs (France 2012). That increases in *O* would be positively related to the number of feeding links and linkage density in a web is not surprising, as omnivorous species add more dietary interactions and complexity to a web compared to a community dominated by specialist feeders (Montoya et al. 2006; Dezerald et al. 2013). This may be particularly important in frequently disturbed headwater networks, as generalist and omnivorous feeders have been noted to shorten recovery time and promote fast recolonization after a community is disturbed (Rosi-Marshall and Wallace 2002). The significant associations between *O* and a variety of metrics related to community stability lend to the hypothesis that omnivory plays an important role in the function and structure of stream food webs.

When we model the effects of removing *O* ("no-*O*" webs), there is dramatic variation in other structural metrics highlighting that *O* is integral to the shape and interaction dynamics of these food webs. This modeling exercise also supports the idea that *O* is vital to web stability as the no-*O* food webs are negatively associated with *Co*, linkage density, and predator:prey ratios; which have been positively related to stability (Polis 1991; McCann et al. 1998). Interestingly, early food web theoretical framework (Pimm and Lawton 1987) and also some recent research (May 1983; Zhao et al. 2019) has disregarded *O* in food web studies, citing its overwhelming complexity or unnecessary inclusion as reasons to overlook this type of interaction. My results show that by incorporating *O* into theoretical and empirical studies we can indeed gain a better understanding of the functioning and organization of food webs in stream networks.

5. Limitations

It is important to keep in mind that in any study of food webs, modeling captures only a snapshot in time of how these communities are structured, as food webs are known to vary temporally (Warren 1989; Closs and Lake 1994), though the sampling here is consistent in using only using summer food webs to minimize these effects. Thus, inferences made from these results may only be applicable to habitats experiencing similar seasonal and climatic conditions. In addition, not all dietary interactions can be captured via literature review, lab experimentation, or dietary analysis; meaning all empirically derived webs are most likely incomplete. I used a combination of dietary studies to capture the most complete set of available interactions possible. The stream community data used in this study, while collected by professionals, was conducted for different projects during different years. This introduces unavoidable variation in effort of sampling groups and yearly conditions a stream site may have been exposed to. To minimize these differences, I used only data collected in a 17-year span from the same season and utilized the distribute-parents-among-children method recommended by Cuffney *et al.* (2007) to standardize variations in invertebrate taxonomic resolution among studies. In addition, while I did not purposefully avoid site locations of minor ecological disturbance (tree blow-downs due to snow or wind) I did not include any surveys that fell within years of major environmental events (i.e. flood of 1996 or drought of 2015). Though these issues exist, the results of this study still shed light on how food web structures change along geophysical gradients within a single watershed, a component currently missing from the growing body of food web research in aquatic ecology.

6. Conclusions

Ecological network theory and the construction of connectance food webs allows researchers to analyze entire communities to better understand their structure and function. In this study I used network theory to explore 18 connectance webs within a single headwater system along multiple geophysical gradients. I show that food web structures varied significantly in streams draining small basin areas (<110 ha) when compared with webs from streams that drain medium/large basin areas (300-6,500 ha). In addition, the steepness of stream slope is strongly associated with overall web structure. Through this analysis, these local and large-scale geophysical aspects are shown to play a role in determining habitat template composition in headwater streams and therefore influence species distributions and dynamics within a system. High levels of stability in downstream sites may also be due to the increased levels of omnivory seen in these habitats, though this feeding mechanism is prevalent throughout the headwater study network. The variation in structural metrics seen along the headwater gradient show a pattern of increasing food web stability lower in the system, which may be attributed to a combination of unique headwater habitats, hydrology, and disturbance regimes. This study has implications for future predictions of how food webs may be expected to change within a single watershed and with changes in surrounding landscape attributes.

7. References

Abrams, P.A. & Ginzburg, L.R. (2000). The nature of predation: prey dependent, ratio dependent or neither? *Trends in Ecology & Evolution*, 15, 337–341.

Banerjee, A., Banerjee, M., Mukherjee, J., Rakshit, N. & Ray, S. (2016). Trophic relationships and ecosystem functioning of Bakreswar Reservoir, India. *Ecological Informatics*, 36, 50–60.

Belgrano, A. (2005). *Aquatic food webs: an ecosystem approach*. Oxford biology. Oxford University Press, Oxford.

Bellmore, J.R., Baxter, C.V. & Connolly, P.J. (2015). Spatial complexity reduces interaction strengths in the meta-food web of a river floodplain mosaic. *Ecology*, 96, 274–283.

Carpenter, S.R., Kraft, C.E., Wright, R., He, X., Soranno, P.A. & Hodgson, J.R. (1992). Resilience and resistance of a lake phosphorus cycle before and after food web manipulation. *The American Naturalist*, 140, 781–798.

Closs, G.P. & Lake, P.S. (1994). Spatial and temporal variation in the structure of an intermittent-stream food web. *Ecological Monographs*, 64, 2–21.

Cohen, J.E., Schittler, D.N., Raffaelli, D.G. & Reuman, D.C. (2009). Food webs are more than the sum of their tritrophic parts. *Proceedings of the National Academy of Sciences of the United States of America*, 106, 22335–22340.

Cohen, J.E. & Stephens, D.W. (1978). *Food Webs and Niche Space*. Princeton University Press.

Colvin, S.A.R., Sullivan, S.M.P., Shirey, P.D., Colvin, R.W., Winemiller, K.O., Hughes, R.M., *et al.* (2019). Headwater streams and wetlands are critical for sustaining fish, fisheries, and ecosystem services. *Fisheries*, 44, 73–91.

Cross, W.F., Baxter, C.V., Rosi-Marshall, E.J., Hall, R.O., Kennedy, T.A., Donner, K.C., *et al.* (2013). Food-web dynamics in a large river discontinuum. *Ecological Monographs*, 83, 311–337.

Cuffney, T.F., Bilger, M.D. & Haigler, A.M. (2007). Ambiguous taxa: effects on the characterization and interpretation of invertebrate assemblages. *Journal of the North American Benthological Society*, 26, 286–307.

De Angelis, D.L. (1975). Stability and connectance in food web models. *Ecology*, 56, 238–243.

Delmas, E., Besson, M., Brice, M.-H., Burkle, L., Dalla Riva, G.V., Fortin, M.-J., *et al.* (2017). Analyzing ecological networks of species interactions.

Dézerald, O., Leroy, C., Corbara, B., Carrias, J.-F., Pélozuelo, L., Dejean, A., *et al.* (2013). Food-web structure in relation to environmental gradients and predator-prey ratios in tank-bromeliad ecosystems. *PLoS ONE*, 8, e71735.

Dunne, J.A., Williams, R.J. & Martinez, N.D. (2002*a*). Food-web structure and network theory: The role of connectance and size. *Proceedings of the National Academy of Sciences*, 99, 12917–12922.

Dunne, J.A., Williams, R.J. & Martinez, N.D. (2002*b*). Network structure and biodiversity loss in food webs: robustness increases with connectance. *Ecology Letters*, 5, 558–567.

Emmerson, M. & Yearsley, J.M. (2004). Weak interactions, omnivory and emergent food-web properties. *Proceedings: Biological Sciences*, 271, 397–405.

Fagan, W.F. (1997). Omnivory as a stabilizing feature of natural communities. *The American Naturalist*, 150, 554–567.

Fausch, K., Torgersen, C., Baxter, C. & Li, H. (2002). Landscapes to riverscapes: Bridging the gap between research and conservation of stream fishes. *Bioscience*, 52, 483–498.

Finke, D.L. & Denno, R.F. (2004). Predator diversity dampens trophic cascades. *Nature; London*, 429, 407–10.

Frady, C., Johnson, S. & Li, J. (2006). Stream macroinvertebrate community responses as legacies of forest harvest at the H.J. Andrews Experimental Forest, Oregon, 13.

France, R.L. (2012). Omnivory, vertical food-web structure and system productivity: stable isotope analysis of freshwater planktonic food webs. *Freshwater Biology*, 57, 787–794.

Gardner, M.R. & Ashby, W.R. (1970). Connectance of large dynamic (cybernetic) systems: critical values for stability. *Nature*, 228, 784–784.

Gellner, G., McCann, K., Křivan, A.E.V. & McPeek, E.M.A. (2012). Reconciling the omnivory-stability debate. *The American Naturalist*, 179, 22–37.

Gilbert, A.J. (2009). Connectance indicates the robustness of food webs when subjected to species loss. *Ecological Indicators*, 9, 72–80.

Grant, E.H.C., Lowe, W.H. & Fagan, W.F. (2007). Living in the branches: population dynamics and ecological processes in dendritic networks. *Ecology Letters*, 10, 165–175.

Gray, C., Figueroa, D.H., Hudson, L.N., Ma, A., Perkins, D. & Woodward, G. (2015). Joining the dots: An automated method for constructing food webs from compendia of published interactions. *Food Webs*, 5, 11–20.

Gregory, S.V. (1980). Effects of light, nutrients, and grazers on periphyton communitites in streams. Doctoral. Oregon State University.

Gregory, S.V., Swanson, F.J., McKee, W.A. & Cummins, K.W. (1991). An ecosystem perspective of riparian zones. *BioScience*, 41, 540–551.

Heaston, E.D., Kaylor, M.J. & Warren, D.R. (2018). Aquatic food web response to patchy shading along forested headwater streams. *Can. J. Fish. Aquat. Sci.*, 75, 2211–2220.

Hudson Lawrence N., Emerson Rob, Jenkins Gareth B., Layer Katrin, Ledger Mark E., Pichler Doris E., *et al.* (2012). Cheddar: analysis and visualisation of ecological communities in R. *Methods in Ecology and Evolution*, 4, 99–104.

Johnson, S.L., Grant, G.E., Swanson, F.J. & Wemple, B.C. (1996). Lessons from a flood: an integrated view of the February 1996 flood in the McKenzie River basin. *American Institute of Hydrology*, 159–167.

Johnson, S.; Frady, C. 2019. Headwater Stream Macroinvertebrates of the H.J. Andrews Experimental Forest, Oregon, 2003-2004. Long-Term Ecological Research. Forest Science Data Bank, Corvallis, OR. [Database]. Available: http://andlter.forestry.oregonstate.edu/data/abstract.aspx?dbcode=SA022 (2 December 2019) DOI:http://dx.doi.org/10.6073/pasta/0fd89ea87c5b13959209a6e2f64a501b.

Jonsson, M., Johansson, F., Karlsson, C. & Brodin, T. (2007). Intermediate predator impact on consumers weakens with increasing predator diversity in the presence of a top-predator. *Acta Oecologica*, 31, 79–85.

Kaylor, M.J. & Warren, D.R. (2017). Linking riparian shade and the legacies of forest management to fish and vertebrate biomass in forested streams. *Ecosphere*, 8, e01845.

Kratina Pavel, Greig Hamish S., Thompson Patrick L., Carvalho-Pereira Ticiana S. A. & Shurin Jonathan B. (2012). Warming modifies trophic cascades and eutrophication in experimental freshwater communities. *Ecology*, 93, 1421–1430.

Lake, P.S. (2000). Disturbance, patchiness, and diversity in streams. *Journal of the North American Benthological Society*, 19, 573–592.

Larsen, D.P., Kaufmann, P.R., Kincaid, T.M. & Urquhart, N.S. (2004). Detecting persistent change in the habitat of salmon-bearing streams in the Pacific Northwest. *Canadian Journal of Fisheries and Aquatic Sciences*, 61, 283–291.

Long, Z.T., Bruno, J.F. & Duffy, J.E. (2011). Food chain length and omnivory determine the stability of a marine subtidal food web. *Journal of Animal Ecology*, 80, 586–594.

Lowe, W.H. & Likens, G.E. (2005). Moving Headwater Streams to the Head of the Class. *BioScience*, 55, 196–197.

May, R. (1983). The structure of food webs. *Nature*, 301, 566.

McCann, K. & Hastings, A. (1997). Re–evaluating the omnivory–stability relationship in food webs. *Proceedings of the Royal Society of London. Series B: Biological Sciences*, 264, 1249–1254.

McCann, K., Hastings, A. & Huxel, G.R. (1998). Weak trophic interactions and the balance of nature. *Nature; London*, 395, 794–798.

Melián, C.J. & Bascompte, J. (2002). Food web structure and habitat loss. *Ecology Letters*, 5, 37–46.

Monteiro, A.B. & Faria, L.D.B. (2016). The interplay between population stability and food-web topology predicts the occurrence of motifs in complex food-webs. *Journal of Theoretical Biology*, 409, 165–171.

Montoya, J.M., Pimm, S.L. & Solé, R.V. (2006). Ecological networks and their fragility. *Nature*, 442, 259–264.

Neutel, A.-M., Heesterbeek, J.A.P., Van De Koppel, J., Hoenderboom, G., Vos, A., Kaldeway, C., *et al.* (2007). Reconciling complexity with stability in naturally assembling food webs. *Nature; London*, 449, 599–602.

Paine, R.T. (1980). Food Webs: Linkage, Interaction Strength and Community Infrastructure. *Journal of Animal Ecology*, 49, 667–685.

Parker, S.M. & Huryn, A.D. (2013). Disturbance and productivity as codeterminants of stream food web complexity in the Arctic. *Limnology and Oceanography*, 58, 2158–2170.

Penaluna, B.E., Railsback, S.F., Dunham, J.B., Johnson, S., Bilby, R.E. & Skaugset, A.E. (2015). The role of the geophysical template and environmental regimes in controlling stream-living trout populations. *Canadian Journal of Fisheries and Aquatic Sciences*, 72, 893–901.

Peterson, E.E., Ver Hoef, J.M., Isaak, D.J., Falke, J.A., Fortin, M.-J., Jordan, C.E., *et al.* (2013). Modelling dendritic ecological networks in space: an integrated network perspective. *Ecology Letters*, 16, 707–719.

Pillai, P., Gonzalez, A. & Loreau, M. (2011). Metacommunity theory explains the emergence of food web complexity. *Proceedings of the National Academy of Sciences*, 108, 19293–19298.

Pimm, S.L. & Lawton, J.H. (1977). Number of trophic levels in ecological communities. *Nature*, 268.

Pimm, S.L. & Lawton, J.H. (1978). On feeding on more than one trophic level. *Nature*, 275, 542.

Pimm, S.L., Lawton, J.H. & Cohen, J.E. (1991). Food web patterns and their consequences. *Nature*, 350.

Pimm, S.L. (2002). *Food webs*. University of Chicago Press, Chicago.

Poff, N.L. & Ward, J.V. (1990). Physical habitat template of lotic systems: Recovery in the context of historical pattern of spatiotemporal heterogeneity. *Environmental Management*, 14, 629.

Poisot, T. & Gravel, D. (2014). When is an ecological network complex? Connectance drives degree distribution and emerging network properties. *PeerJ*, 2, e251.

Polis, G.A. (1991). Complex trophic interactions in deserts: An empirical critique of food-web theory. *The American Naturalist*, 138, 123–155.

Polis, G.A. & Strong, D.R. (1996). Food web complexity and community dynamics. *The American Naturalist*, 147, 813–846.

Power, M.E. (1992). Habitat heterogeneity and the functional signifiance of fish in river food webs. *Ecology*, 73, 1675–1688.

Power, M.E. & Dietrich, W.E. (2002). Food webs in river networks. *Ecological Research*, 17, 451–471.

Power, M.E., Holomuzki, J.R. & Lowe, R.L. (2013). Food webs in Mediterranean rivers. *Hydrobiologia*, 719, 119–136.

Rosi-Marshall, E.J. & Wallace, J.B. (2002). Invertebrate food webs along a stream resource gradient. *Freshwater Biology*, 47, 129–141.

Sabo, J.L., Finlay, J.C., Kennedy, T. & Post, D.M. (2010). The role of discharge variation in scaling of drainage area and food chain length in rivers. *Science*, 330, 965–967.

Sabo, J.L., Finlay, J.C. & Post, D.M. (2009). Food Chains in Freshwaters. *Annals of the New York Academy of Sciences*, 1162, 187–220.

Schindler, D.E., Armstrong, J.B. & Reed, T.E. (2015). The portfolio concept in ecology and evolution. *Frontiers in Ecology and the Environment*, 13, 257–263.

Smits, A.P., Schindler, D.E. & Brett, M.T. (2015). Geomorphology controls the trophic base of stream food webs in a boreal watershed. *Ecology*, 96, 1775–1782.

Stouffer, D.B., Camacho, J. & Amaral, L.A.N. (2006). A robust measure of food web intervality. *PNAS*, 103, 19015–19020.

Thompson, R.M., Dunne, J.A. & Woodward, G. (2012). Freshwater food webs: towards a more fundamental understanding of biodiversity and community dynamics. *Freshwater Biology*, 57, 1329–1341.

Thompson, R.M., Hemberg, M., Starzomski, B.M. & Shurin, J.B. (2007). Trophic levels and trophic tangles: the prevalence of omnivory in real food webs. *Ecology*, 88, 612–617.

Thompson, R.M. & Townsend, C.R. (2005*a*). Energy availability, spatial heterogeneity and ecosystem size predict food-web structure in streams. *Oikos*, 108, 137–148.

Thompson, R.M. & Townsend, C.R. (2005*b*). Food-web topology varies with spatial scale in a patchy environment. *Ecology*, 86, 1916–1925.

Thoms, M.C., Delong, M.D., Flotemersch, J.E. & Collins, S.E. (2017). Physical heterogeneity and aquatic community function in river networks: A case study from the Kanawha River Basin, USA. *Geomorphology*, 290, 277–287.

Townsend, C.R. (1989). The patch dynamics concept of stream community ecology. *Journal of the North American Benthological Society*, 8, 36–50.

Vannote, R.L., Minshall, G.W., Cummins, K.W., Sedell, J.R. & Cushing, C.E. (1980). The river continuum concept. *Canadian Journal of Fisheries and Aquatic Sciences*, 37, 130–137.

Vermaat, J.E., Dunne, J.A. & Gilbert, A.J. (2009). Major dimensions in food-web structure properties. *Ecology*, 90, 278–282.

Ward, A.S., Wondzell, S.M., Schmadel, N.M., Herzog, S., Zarnetske, J.P., Baranov, V., *et al.* (2019). Spatial and temporal variation in river corridor exchange across a 5th order mountain stream network. *Hydrology and Earth System Sciences Discussions*, 1–39.

Warfe, D.M., Jardine, T.D., Pettit, N.E., Hamilton, S.K., Pusey, B.J., Bunn, S.E., *et al.* (2013). Productivity, disturbance and ecosystem size have no influence on food chain length in seasonally connected rivers. *PLoS ONE*, 8, 66240.

Warren, D.R., Collins, S.M., Purvis, E.M., Kaylor, M.J. & Bechtold, H.A. (2017). Spatial variability in light yields colimitation of primary production by both light and nutrients in a forested stream ecosystem. *Ecosystems*, 20, 198–210.

Warren, D.R., Keeton, W.S., Kiffney, P.M., Kaylor, M.J., Bechtold, H.A. & Magee, J. (2016). Changing forests-changing streams: riparian forest stand development and ecosystem function in temperate headwaters. *Ecosphere*, 7, e01435.

Warren, P.H. (1989). Spatial and temporal variation in the structure of a freshwater food web. *Oikos*, 55, 299–311.

Wenger, S.J., Isaak, D.J., Luce, C.H., Neville, H.M., Fausch, K.D., Dunham, J.B., *et al.* (2011). Flow regime, temperature, and biotic interactions drive differential declines of trout species under climate change. *Proceedings of the National Academy of Sciences*, 108, 14175–14180.

Williams, R.J. & Martinez, N.D. (2000). Simple rules yield complex food webs, 404, 4.

Woodward, G. & Hildrew, A.G. (2002). Body-size determinants of niche overlap and intraguild predation within a complex food web. *Journal of Animal Ecology*, 71, 1063–1074.

Woodward, G., Papantoniou, G., Edwards, F. & Lauridsen, R.B. (2008). Trophic trickles and cascades in a complex food web: impacts of a keystone predator on stream community structure and ecosystem processes. *Oikos*, 117, 683–692.

Wootton, K.L. (2017). Omnivory and stability in freshwater habitats: Does theory match reality? *Freshwater Biology*, 62, 821–832.

Zhao, Q., Brink, P.J.V. den, Carpentier, C., Wang, Y.X.G., Rodríguez-Sánchez, P., Xu, C., *et al.* (2019). Horizontal and vertical diversity jointly shape food web stability against small and large perturbations. *Ecology Letters*, 22, 1152–1162.

Ziegler, J.P., Gregory-Eaves, I. & Solomon, C.T. (2017). Refuge increases food chain length: modeled impacts of littoral structure in lake food webs. *Oikos*, 126, 1347–1356.

Zook, A.E., Eklof, A., Jacob, U. & Allesina, S. (2011). Food webs: Ordering species according to body size yields high degree of intervality. *Journal of Theoretical Biology*, 271, 106–113.

Appendix A. List of all taxa present within the 18 study food webs.

Taxonomic Identification									Food Web Site			
kingdom	**phylum**	**class**	**subclass**	**order**	**family**	**subfamily**	**genus**	**species**	**M764**	**M770**	**L415_WS1**	**L432_WS2**
animalia	arthropoda	Insecta		Coleoptera	Dytiscidae		Oreodytes					
animalia	arthropoda	Insecta		Coleoptera	Dytiscidae				x	x		
animalia	arthropoda	Insecta		Coleoptera	Elmidae		Ampumixis	dispar				
animalia	arthropoda	Insecta		Coleoptera	Elmidae		Ampumixis		x			
animalia	arthropoda	Insecta		Coleoptera	Elmidae		Heterlimnius		x	x		
animalia	arthropoda	Insecta		Coleoptera	Elmidae		Lara			x	x	
animalia	arthropoda	Insecta		Coleoptera	Elmidae		Optioservus			x		
animalia	arthropoda	Insecta		Coleoptera	Elmidae				x	x	x	x
animalia	arthropoda	Insecta		Coleoptera	Psephenidae		Acneus					
animalia	arthropoda	Insecta		Coleoptera	Ptilodactylidae		Anchycteis					
animalia	arthropoda	Insecta		Coleoptera	Staphylinidae					x		
animalia	arthropoda	Maxillopoda	Copepoda	Cyclopoida					x	x	x	x
animalia	crustacea	Malacostraca		Decapoda								
animalia	arthropoda	Branchiopoda		Diplostraca	Chydoridae						x	
animalia	arthropoda	Insecta		Diptera	Blephariceridae							
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae		Atrichopogon		x			
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae		Bezzia/Palpomyia		x		x	x
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae		Ceratopogon					
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae		Forcipomyia			x		
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae		Palpomyia/Bezzia					
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae		Probezzia		x	x	x	
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae				x	x		x
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae	Forcipomyiinae						
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae	Ceratopogoninae						
animalia	arthropoda	Insecta		Diptera	Chironomidae	Chironominae	Chironomini					
animalia	arthropoda	Insecta		Diptera	Chironomidae	Non-Tanypodinae						
animalia	arthropoda	Insecta		Diptera	Chironomidae	Orthocladiinae	Brillia					
animalia	arthropoda	Insecta		Diptera	Chironomidae	Orthocladiinae	Corynoneura					
animalia	arthropoda	Insecta		Diptera	Chironomidae	Orthocladiinae	Cricotopus					

kingdom	phylum	class	subclass	order	family	subfamily	genus	species	M764	M770	L415_WS1	L432_WS2
animalia	arthropoda	Insecta		Diptera	Chironomidae	Orthocladiinae	Cricotopus/ Orthocladius					
animalia	arthropoda	Insecta		Diptera	Chironomidae	Orthocladiinae			x	x	x	x
animalia	arthropoda	Insecta		Diptera	Chironomidae	Tanypodinae			x	x	x	x
animalia	arthropoda	Insecta		Diptera	Chironomidae	Tanytarsini			x	x	x	x
animalia	arthropoda	Insecta		Diptera	Chironomidae				x	x	x	x
animalia	arthropoda	Insecta		Diptera	Chironomidae/ Ceratopogonidae							x
animalia	arthropoda	Insecta		Diptera	Dixidae		Dixa		x	x	x	
animalia	arthropoda	Insecta		Diptera	Dixidae				x		x	x
animalia	arthropoda	Insecta		Diptera	Empididae		Chelifera		x			
animalia	arthropoda	Insecta		Diptera	Empididae		Clinocera		x	x		x
animalia	arthropoda	Insecta		Diptera	Empididae		Hemerodromia		x			x
animalia	arthropoda	Insecta		Diptera	Empididae		Metachela					
animalia	arthropoda	Insecta		Diptera	Empididae		Oreogeton			x		x
animalia	arthropoda	Insecta		Diptera	Empididae		Oreothalia					
animalia	arthropoda	Insecta		Diptera	Empididae				x	x		x
animalia	arthropoda	Insecta		Diptera	Psychodidae		Maruina		x	x		
animalia	arthropoda	Insecta		Diptera	Psychodidae		Pericoma					
animalia	arthropoda	Insecta		Diptera	Psychodidae						x	
animalia	arthropoda	Insecta		Diptera	Simuliidae		Prosimulium			x		
animalia	arthropoda	Insecta		Diptera	Simuliidae		Simulium		x			
animalia	arthropoda	Insecta		Diptera	Simuliidae				x			x
animalia	arthropoda	Insecta		Diptera	Thaumaleidae		Thaumalea					x
animalia	arthropoda	Insecta		Diptera	Thaumaleidae							
animalia	arthropoda	Insecta		Diptera	Tipulidae		Antocha		x	x		
animalia	arthropoda	Insecta		Diptera	Tipulidae		Hexatoma			x	x	x
animalia	arthropoda	Insecta		Diptera	Tipulidae		Hexatoma/Limnophila					
animalia	arthropoda	Insecta		Diptera	Tipulidae		Limonia					
animalia	arthropoda	Insecta		Diptera	Tipulidae		Tipula				x	
animalia	arthropoda	Insecta		Diptera	Tipulidae				x	x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Ameletidae		Ameletus		x	x	x	x

kingdom	phylum	class	subclass	order	family	subfamily	genus	species	M764	M770	L415_WS1	L432_WS2
animalia	arthropoda	Insecta		Ephemeroptera	Baetidae		Acentrella					
animalia	arthropoda	Insecta		Ephemeroptera	Baetidae		Baetis	bicaudatus				
animalia	arthropoda	Insecta		Ephemeroptera	Baetidae		Baetis	tricaudatus				
animalia	arthropoda	Insecta		Ephemeroptera	Baetidae		Baetis		x		x	x
animalia	arthropoda	Insecta		Ephemeroptera	Baetidae		Diphetor				x	x
animalia	arthropoda	Insecta		Ephemeroptera	Baetidae		Heterocloeon					
animalia	arthropoda	Insecta		Ephemeroptera	Baetidae				x	x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Attenella					
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Attenella/Ephemerella/ Serratella					
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Caudatella	hystrix				
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Caudatella		x	x		
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Drunella	coloradensis/ flavilinea				
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Drunella	doddsii				
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Drunella	spinifera				
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Drunella		x	x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Ephemerella					
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Ephemerella/Serratella					x
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Serratella		x			
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae				x	x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Heptageniidae		Cinygma					
animalia	arthropoda	Insecta		Ephemeroptera	Heptageniidae		Cinygmula		x	x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Heptageniidae		Epeorus	grandis				
animalia	arthropoda	Insecta		Ephemeroptera	Heptageniidae		Epeorus		x	x		x
animalia	arthropoda	Insecta		Ephemeroptera	Heptageniidae		Ironodes				x	x
animalia	arthropoda	Insecta		Ephemeroptera	Heptageniidae		Rhithrogena		x	x		
animalia	arthropoda	Insecta		Ephemeroptera	Heptageniidae				x	x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Leptophlebiidae		Paraleptophlebia		x	x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Leptophlebiidae							
animalia	arthropoda	Hexanauplia	Copepoda	Harpacticoida					x	x	x	x
animalia	arthropoda	Insecta		Hemiptera	Gerridae		Gerris				x	x

kingdom	phylum	class	subclass	order	family	subfamily	genus	species	M764	M770	L415_WS1	L432_WS2
animalia	arthropoda	Insecta		Hemiptera	Veliidae		Microvelia					
animalia	Mollusca	Gastropoda		Littorinimorpha	Hydrobiidae						x	x
animalia	arthropoda	Insecta		Megaloptera	Corydalidae		Orohermes	crepusculus				
animalia	arthropoda	Insecta		Megaloptera	Corydalidae		Orohermes					
animalia	arthropoda	Insecta		Megaloptera	Corydalidae							
animalia	arthropoda	Insecta		Megaloptera	Sialidae		Sialis					
animalia	arthropoda	Gastropoda		Mesogastropoda	Pleuroceridae		Juga				x	x
animalia	Mollusca	Gastropoda		Neotaenioglossa	Hydrobiidae		Pristinicola					
animalia	arthropoda	Insecta		Odonata	Cordulegastridae		Cordulegaster				x	
animalia	arthropoda	Insecta		Odonata	Gomphidae		Octogomphus				x	x
animalia	arthropoda	Insecta		Oligochaeta					x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Capniidae							
animalia	arthropoda	Insecta		Plecoptera	Chloroperlidae		Alloperla					
animalia	arthropoda	Insecta		Plecoptera	Chloroperlidae		Kathroperla				x	x
animalia	arthropoda	Insecta		Plecoptera	Chloroperlidae		Paraperla					
animalia	arthropoda	Insecta		Plecoptera	Chloroperlidae		Suwallia		x			
animalia	arthropoda	Insecta		Plecoptera	Chloroperlidae		Sweltsa		x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Chloroperlidae				x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Chloroperlidae	Chloroperlinae						
animalia	arthropoda	Insecta		Plecoptera	Leuctridae		Despaxia		x		x	x
animalia	arthropoda	Insecta		Plecoptera	Leuctridae		Moselia					x
animalia	arthropoda	Insecta		Plecoptera	Leuctridae		Paraleuctra					
animalia	arthropoda	Insecta		Plecoptera	Leuctridae							
animalia	arthropoda	Insecta		Plecoptera	Leuctridae/Capniidae				x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Nemouridae		Amphinemura					
animalia	arthropoda	Insecta		Plecoptera	Nemouridae		Malenka		x		x	x
animalia	arthropoda	Insecta		Plecoptera	Nemouridae		Soyedina					
animalia	arthropoda	Insecta		Plecoptera	Nemouridae		Visoka	Cataractae				
animalia	arthropoda	Insecta		Plecoptera	Nemouridae		Visoka			x		
animalia	arthropoda	Insecta		Plecoptera	Nemouridae	Nemourinae	Zapada		x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Nemouridae				x	x	x	x

kingdom	phylum	class	subclass	order	family	subfamily	genus	species	M764	M770	L415_WS1	L432_WS2
animalia	arthropoda	Insecta		Plecoptera	Peltoperlidae		Soliperla					
animalia	arthropoda	Insecta		Plecoptera	Peltoperlidae		Yoraperla		x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Peltoperlidae				x	x		x
animalia	arthropoda	Insecta		Plecoptera	Perlidae		Calineuria	californica				
animalia	arthropoda	Insecta		Plecoptera	Perlidae		Calineuria		x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Perlidae	Acroneuriinae	Doroneuria		x	x		
animalia	arthropoda	Insecta		Plecoptera	Perlidae		Hesperoperla					
animalia	arthropoda	Insecta		Plecoptera	Perlidae				x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Perlidae/Perlodidae				x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Perlodidae		Kogotus/Rickera		x	x		
animalia	arthropoda	Insecta		Plecoptera	Perlodidae		Megarcys		x	x		
animalia	arthropoda	Insecta		Plecoptera	Perlodidae		Skwala					
animalia	arthropoda	Insecta		Plecoptera	Perlodidae				x	x	x	
animalia	arthropoda	Insecta		Plecoptera	Pteronarcydiae		Pteronarcys		x	x		
animalia	arthropoda	Insecta		Plecoptera	Taeniopterygidae		Doddsia/Taenionema		x	x		
animalia	arthropoda	Insecta		Trichoptera	Apataniidae		Apatania					
animalia	arthropoda	Insecta		Trichoptera	Brachycentriade		Brachycentrus					
animalia	arthropoda	Insecta		Trichoptera	Brachycentridae		Micrasema		x	x	x	x
animalia	arthropoda	Insecta		Trichoptera	Brachycentridae				x	x		
animalia	arthropoda	Insecta		Trichoptera	Calamoceratidae		Heteroplectron	Californicum				
animalia	arthropoda	Insecta		Trichoptera	Calamoceratidae		Heteroplectron					
animalia	arthropoda	Insecta		Trichoptera	Glossosomatidae		Anagapetus					
animalia	arthropoda	Insecta		Trichoptera	Glossosomatidae	Glossosomatinae	Glossosoma		x	x	x	
animalia	arthropoda	Insecta		Trichoptera	Glossosomatidae				x	x	x	x
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae	Arctopsychinae	Arctopsyche	grandis				
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae		Arctopsyche		x	x		
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae	Hydropsychinae	Ceratopsyche				x	
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae		Diplectrona					
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae		Hydropsyche					
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae		Parapsyche	elsis				
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae		Parapsyche		x	x		x

kingdom	phylum	class	subclass	order	family	subfamily	genus	species	M764	M770	L415_WS1	L432_WS2
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae				x	x	x	x
animalia	arthropoda	Insecta		Trichoptera	Hydroptilidae		Palaeagapetus					
animalia	arthropoda	Insecta		Trichoptera	Lepidostomatidae	Lepidostomatinae	Lepidostoma			x	x	x
animalia	arthropoda	Insecta		Trichoptera	Limnephilidae		Cryptochia					
animalia	arthropoda	Insecta		Trichoptera	Limnephilidae		Ecclisomyia		x			
animalia	arthropoda	Insecta		Trichoptera	Limnephilidae		Philocasca					
animalia	arthropoda	Insecta		Trichoptera	Limnephilidae		Psychoglypha					
animalia	arthropoda	Insecta		Trichoptera	Limnephilidae						x	
animalia	arthropoda	Insecta		Trichoptera	Odontoceridae		Namamyia					
animalia	arthropoda	Insecta		Trichoptera	Philopotamidae		Dolophilodes				x	
animalia	arthropoda	Insecta		Trichoptera	Philopotamidae		Wormaldia				x	
animalia	arthropoda	Insecta		Trichoptera	Philopotamidae					x	x	x
animalia	arthropoda	Insecta		Trichoptera	Polycentropodidae		Polycentropus				x	x
animalia	arthropoda	Insecta		Trichoptera	Rhyacophilidae		Rhyacophila		x	x	x	x
animalia	arthropoda	Insecta		Trichoptera	Uenoidae		Neophylax		x	x	x	x
animalia	arthropoda	Insecta		Trichoptera	Uenoidae		Neothremma					
animalia	arthropoda	Insecta		Trichoptera	Uenoidae				x			
animalia	chordata	amphibia		urodela	Plethodontidae		Plethodon	dunni				
animalia	arthropoda	Bivalvia	Heterodonta	Veneroida	Sphaeriidae						x	
animalia	arthropoda	Arachnida	Acari						x	x	x	x
animalia	arthropoda	Hexanauplia	Copepoda						x	x		
animalia	cnidaria	Hydrozoa	Hydroida						x			
animalia	arthropoda	Gastropoda								x		
animalia	arthropoda	Insecta					Meringodixa				x	x
animalia	arthropoda	Ostracoda							x	x	x	x
animalia	arthropoda	Turbellaria							x	x	x	x
protista	ochrophyta	Bacillariophyceae		Diatoms					x	x	x	x
animalia	arthropoda	CPOM/FPOM							x	x	x	x
animalia	arthropoda	Detritus							x	x	x	x
plantae	chlorophyta	Algae							x	x	x	x
animalia	chordata	amphibia		anura	ascaphidae		Ascaphus					

kingdom	phylum	class	subclass	order	family	subfamily	genus	species	M764	M770	L415_WS1	L432_WS2
animalia	chordata	Actinopterygii		Cypriniformes	Cyprinidae		Rhinichthys	Cataractae				
animalia	chordata	Actinopterygii		Cypriniformes	Cyprinidae		Rhinichthys	Macrocheilus				
animalia	chordata	Actinopterygii		Cypriniformes	Cyprinidae		Rhinichthys	Osculus				
animalia	chordata	actinopterygii		Salmoniformes	Salmonidae		Oncorhynchus	Clarkii	x	x		
animalia	chordata	Actinopterygii		Salmoniformes	Salmonidae		Oncorhynchus	Mykiss				
animalia	chordata	Actinopterygii		Scorpaeniformes	Cottidae		Cottus	bairdi				
animalia	chordata	Actinopterygii		Scorpaeniformes	Cottidae		Cottus	beldingi				
animalia	chordata	Amphibia		Urodela	Ambystomatidae		Dicamptodon	Tenebrosus	x	x	x	x
kingdom	**phylum**	**class**	**subclass**	**order**	**family**	**subfamily**	**genus**	**species**	**RT_690_WS7**	**RT_690_WS8**	**L643_NBW**	**L624_AW**
animalia	arthropoda	Insecta		Coleoptera	Dytiscidae		Oreodytes					
animalia	arthropoda	Insecta		Coleoptera	Dytiscidae							
animalia	arthropoda	Insecta		Coleoptera	Elmidae		Ampumixis	dispar				
animalia	arthropoda	Insecta		Coleoptera	Elmidae		Ampumixis					
animalia	arthropoda	Insecta		Coleoptera	Elmidae		Heterlimnius				x	
animalia	arthropoda	Insecta		Coleoptera	Elmidae		Lara		x	x	x	x
animalia	arthropoda	Insecta		Coleoptera	Elmidae		Optioservus					
animalia	arthropoda	Insecta		Coleoptera	Elmidae				x	x	x	x
animalia	arthropoda	Insecta		Coleoptera	Psephenidae		Acneus		x	x	x	
animalia	arthropoda	Insecta		Coleoptera	Ptilodactylidae		Anchycteis		x			
animalia	arthropoda	Insecta		Coleoptera	Staphylinidae				x			
animalia	arthropoda	Maxillopoda	Copepoda	Cyclopoida					x	x	x	x
animalia	crustacea	Malacostraca		Decapoda								
animalia	arthropoda	Branchiopoda		Diplostraca	Chydoridae							
animalia	arthropoda	Insecta		Diptera	Blephariceridae							
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae		Atrichopogon		x			x
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae		Bezzia/Palpomyia		x	x	x	x
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae		Ceratopogon				x	
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae		Forcipomyia			x	x	
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae		Palpomyia/Bezzia					
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae		Probezzia					
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae				x	x	x	x

kingdom	phylum	class	subclass	order	family	subfamily	genus	species	RT_690_WS7	RT_690_WS8	L643_NBW	L624_AW
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae	Forcipomyiinae					x	
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae	Ceratopogoninae						
animalia	arthropoda	Insecta		Diptera	Chironomidae	Chironominae	Chironomini					
animalia	arthropoda	Insecta		Diptera	Chironomidae	Non-Tanypodinae						
animalia	arthropoda	Insecta		Diptera	Chironomidae	Orthocladiinae	Brillia					
animalia	arthropoda	Insecta		Diptera	Chironomidae	Orthocladiinae	Corynoneura					
animalia	arthropoda	Insecta		Diptera	Chironomidae	Orthocladiinae	Cricotopus					
animalia	arthropoda	Insecta		Diptera	Chironomidae	Orthocladiinae	Cricotopus/ Orthocladius					
animalia	arthropoda	Insecta		Diptera	Chironomidae	Orthocladiinae			x	x	x	x
animalia	arthropoda	Insecta		Diptera	Chironomidae	Tanypodinae			x	x	x	x
animalia	arthropoda	Insecta		Diptera	Chironomidae	Tanytarsini			x	x	x	x
animalia	arthropoda	Insecta		Diptera	Chironomidae				x	x	x	x
animalia	arthropoda	Insecta		Diptera	Chironomidae/ Ceratopogonidae							
animalia	arthropoda	Insecta		Diptera	Dixidae		Dixa		x	x	x	x
animalia	arthropoda	Insecta		Diptera	Dixidae				x	x	x	x
animalia	arthropoda	Insecta		Diptera	Empididae		Chelifera					x
animalia	arthropoda	Insecta		Diptera	Empididae		Clinocera		x	x	x	
animalia	arthropoda	Insecta		Diptera	Empididae		Hemerodromia					
animalia	arthropoda	Insecta		Diptera	Empididae		Metachela					
animalia	arthropoda	Insecta		Diptera	Empididae		Oreogeton		x	x	x	x
animalia	arthropoda	Insecta		Diptera	Empididae		Oreothalia		x	x	x	x
animalia	arthropoda	Insecta		Diptera	Empididae				x	x	x	x
animalia	arthropoda	Insecta		Diptera	Psychodidae		Maruina					
animalia	arthropoda	Insecta		Diptera	Psychodidae		Pericoma					
animalia	arthropoda	Insecta		Diptera	Psychodidae							
animalia	arthropoda	Insecta		Diptera	Simuliidae		Prosimulium		x	x	x	
animalia	arthropoda	Insecta		Diptera	Simuliidae		Simulium		x			
animalia	arthropoda	Insecta		Diptera	Simuliidae				x	x	x	
animalia	arthropoda	Insecta		Diptera	Thaumaleidae		Thaumalea		x		x	x
animalia	arthropoda	Insecta		Diptera	Thaumaleidae							

kingdom	phylum	class	subclass	order	family	subfamily	genus	species	RT_690_WS7	RT_690_WS8	L643_NBW	L624_AW
animalia	arthropoda	Insecta		Diptera	Tipulidae		Antocha		x			
animalia	arthropoda	Insecta		Diptera	Tipulidae		Hexatoma			x	x	x
animalia	arthropoda	Insecta		Diptera	Tipulidae		Hexatoma/Limnophila		x	x	x	x
animalia	arthropoda	Insecta		Diptera	Tipulidae		Limonia					
animalia	arthropoda	Insecta		Diptera	Tipulidae		Tipula					
animalia	arthropoda	Insecta		Diptera	Tipulidae				x	x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Ameletidae		Ameletus		x	x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Baetidae		Acentrella					
animalia	arthropoda	Insecta		Ephemeroptera	Baetidae		Baetis	bicaudatus				
animalia	arthropoda	Insecta		Ephemeroptera	Baetidae		Baetis	tricaudatus				
animalia	arthropoda	Insecta		Ephemeroptera	Baetidae		Baetis		x		x	x
animalia	arthropoda	Insecta		Ephemeroptera	Baetidae		Diphetor		x	x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Baetidae		Heterocloeon					
animalia	arthropoda	Insecta		Ephemeroptera	Baetidae				x	x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Attenella					
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Attenella/Ephemerella/ Serratella		x	x	x	
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Caudatella	hystrix				
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Caudatella				x	
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Drunella	coloradensis/ flavilinea				
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Drunella	doddsii				
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Drunella	spinifera				
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Drunella		x		x	x
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Ephemerella					
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Ephemerella/Serratella					
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Serratella		x	x		
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae				x	x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Heptageniidae		Cinygma				x	
animalia	arthropoda	Insecta		Ephemeroptera	Heptageniidae		Cinygmula		x	x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Heptageniidae		Epeorus	grandis				
animalia	arthropoda	Insecta		Ephemeroptera	Heptageniidae		Epeorus		x	x	x	x

kingdom	phylum	class	subclass	order	family	subfamily	genus	species	RT_690_WS7	RT_690_WS8	L643_NBW	L624_AW
animalia	arthropoda	Insecta		Ephemeroptera	Heptageniidae		Ironodes		x	x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Heptageniidae		Rhithrogena				x	x
animalia	arthropoda	Insecta		Ephemeroptera	Heptageniidae				x	x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Leptophlebiidae		Paraleptophlebia		x	x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Leptophlebiidae							
animalia	arthropoda	Hexanauplia	Copepoda	Harpacticoida					x	x	x	x
animalia	arthropoda	Insecta		Hemiptera	Gerridae		Gerris					
animalia	arthropoda	Insecta		Hemiptera	Veliidae		Microvelia					
animalia	Mollusca	Gastropoda		Littorinimorpha	Hydrobiidae				x	x	x	x
animalia	arthropoda	Insecta		Megaloptera	Corydalidae		Orohermes	crepusculus				
animalia	arthropoda	Insecta		Megaloptera	Corydalidae		Orohermes				x	
animalia	arthropoda	Insecta		Megaloptera	Corydalidae							
animalia	arthropoda	Insecta		Megaloptera	Sialidae		Sialis		x	x		
animalia	arthropoda	Gastropoda		Mesogastropoda	Pleuroceridae		Juga					
animalia	Mollusca	Gastropoda		Neotaenioglossa	Hydrobiidae		Pristinicola					
animalia	arthropoda	Insecta		Odonata	Cordulegastridae		Cordulegaster					
animalia	arthropoda	Insecta		Odonata	Gomphidae		Octogomphus					
animalia	arthropoda	Insecta		Oligochaeta					x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Capniidae							
animalia	arthropoda	Insecta		Plecoptera	Chloroperlidae		Alloperla		x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Chloroperlidae		Kathroperla		x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Chloroperlidae		Paraperla					
animalia	arthropoda	Insecta		Plecoptera	Chloroperlidae		Suwallia					
animalia	arthropoda	Insecta		Plecoptera	Chloroperlidae		Sweltsa		x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Chloroperlidae							
animalia	arthropoda	Insecta		Plecoptera	Chloroperlidae	Chloroperlinae			x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Leuctridae		Despaxia		x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Leuctridae		Moselia		x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Leuctridae		Paraleuctra					
animalia	arthropoda	Insecta		Plecoptera	Leuctridae							
animalia	arthropoda	Insecta		Plecoptera	Leuctridae/Capniidae				x	x	x	x

kingdom	phylum	class	subclass	order	family	subfamily	genus	species	RT_690_WS7	RT_690_WS8	L643_NBW	L624_AW
animalia	arthropoda	Insecta		Plecoptera	Nemouridae		Amphinemura					
animalia	arthropoda	Insecta		Plecoptera	Nemouridae		Malenka		x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Nemouridae		Soyedina		x	x	x	
animalia	arthropoda	Insecta		Plecoptera	Nemouridae		Visoka	Cataractae				
animalia	arthropoda	Insecta		Plecoptera	Nemouridae		Visoka		x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Nemouridae	Nemourinae	Zapada		x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Nemouridae				x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Peltoperlidae		Soliperla				x	x
animalia	arthropoda	Insecta		Plecoptera	Peltoperlidae		Yoraperla		x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Peltoperlidae						x	x
animalia	arthropoda	Insecta		Plecoptera	Perlidae		Calineuria	californica				
animalia	arthropoda	Insecta		Plecoptera	Perlidae		Calineuria			x		x
animalia	arthropoda	Insecta		Plecoptera	Perlidae	Acroneuriinae	Doroneuria					
animalia	arthropoda	Insecta		Plecoptera	Perlidae		Hesperoperla					
animalia	arthropoda	Insecta		Plecoptera	Perlidae					x	x	x
animalia	arthropoda	Insecta		Plecoptera	Perlidae/Perlodidae				x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Perlodidae		Kogotus/Rickera					
animalia	arthropoda	Insecta		Plecoptera	Perlodidae		Megarcys				x	
animalia	arthropoda	Insecta		Plecoptera	Perlodidae		Skwala					
animalia	arthropoda	Insecta		Plecoptera	Perlodidae				x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Pteronarcydiae		Pteronarcys					
animalia	arthropoda	Insecta		Plecoptera	Taeniopterygidae		Doddsia/Taenionema					
animalia	arthropoda	Insecta		Trichoptera	Apataniidae		Apatania					
animalia	arthropoda	Insecta		Trichoptera	Brachycentriade		Brachycentrus					
animalia	arthropoda	Insecta		Trichoptera	Brachycentridae		Micrasema		x	x	x	x
animalia	arthropoda	Insecta		Trichoptera	Brachycentridae							
animalia	arthropoda	Insecta		Trichoptera	Calamoceratidae		Heteroplectron	Californicum				
animalia	arthropoda	Insecta		Trichoptera	Calamoceratidae		Heteroplectron		x	x		x
animalia	arthropoda	Insecta		Trichoptera	Glossosomatidae		Anagapetus					
animalia	arthropoda	Insecta		Trichoptera	Glossosomatidae	Glossosomatinae	Glossosoma					
animalia	arthropoda	Insecta		Trichoptera	Glossosomatidae						x	x

kingdom	phylum	class	subclass	order	family	subfamily	genus	species	RT_690_WS7	RT_690_WS8	L643_NBW	L624_AW
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae	Arctopsychinae	Arctopsyche	grandis				
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae		Arctopsyche					
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae	Hydropsychinae	Ceratopsyche					
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae		Diplectrona					
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae		Hydropsyche					
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae		Parapsyche	elsis				
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae		Parapsyche		x			
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae				x			x
animalia	arthropoda	Insecta		Trichoptera	Hydroptilidae		Palaeagapetus		x			
animalia	arthropoda	Insecta		Trichoptera	Lepidostomatidae	Lepidostomatinae	Lepidostoma		x	x	x	x
animalia	arthropoda	Insecta		Trichoptera	Limnephilidae		Cryptochia					
animalia	arthropoda	Insecta		Trichoptera	Limnephilidae		Ecclisomyia					
animalia	arthropoda	Insecta		Trichoptera	Limnephilidae		Philocasca		x			
animalia	arthropoda	Insecta		Trichoptera	Limnephilidae		Psychoglypha			x		x
animalia	arthropoda	Insecta		Trichoptera	Limnephilidae				x			
animalia	arthropoda	Insecta		Trichoptera	Odontoceridae		Namamyia		x			
animalia	arthropoda	Insecta		Trichoptera	Philopotamidae		Dolophilodes			x	x	x
animalia	arthropoda	Insecta		Trichoptera	Philopotamidae		Wormaldia			x	x	x
animalia	arthropoda	Insecta		Trichoptera	Philopotamidae				x	x	x	x
animalia	arthropoda	Insecta		Trichoptera	Polycentropodidae		Polycentropus					x
animalia	arthropoda	Insecta		Trichoptera	Rhyacophilidae		Rhyacophila		x	x	x	x
animalia	arthropoda	Insecta		Trichoptera	Uenoidae		Neophylax		x		x	x
animalia	arthropoda	Insecta		Trichoptera	Uenoidae		Neothremma				x	
animalia	arthropoda	Insecta		Trichoptera	Uenoidae						x	
animalia	chordata	amphibia		urodela	Plethodontidae		Plethodon	dunni				
animalia	arthropoda	Bivalvia	Heterodonta	Veneroida	Sphaeriidae				x		x	x
animalia	arthropoda	Arachnida	Acari						x	x	x	x
animalia	arthropoda	Hexanauplia	Copepoda									
animalia	cnidaria	Hydrozoa	Hydroida									
animalia	arthropoda	Gastropoda										
animalia	arthropoda	Insecta					Meringodixa		x	x	x	x

kingdom	phylum	class	subclass	order	family	subfamily	genus	species	RT_690_WS7	RT_690_WS8	L643_NBW	L624_AW
animalia	arthropoda	Ostracoda							x	x	x	x
animalia	arthropoda	Turbellaria							x	x	x	x
protista	ochrophyta	Bacillariophyceae		Diatoms					x	x	x	x
animalia	arthropoda	CPOM/FPOM							x	x	x	x
animalia	arthropoda	Detritus							x	x	x	x
plantae	chlorophyta	Algae							x	x	x	x
animalia	chordata	amphibia		anura	ascaphidae		Ascaphus					
animalia	chordata	Actinopterygii		Cypriniformes	Cyprinidae		Rhinichthys	Cataractae				
animalia	chordata	Actinopterygii		Cypriniformes	Cyprinidae		Rhinichthys	Macrocheilus				
animalia	chordata	Actinopterygii		Cypriniformes	Cyprinidae		Rhinichthys	Osculus				
animalia	chordata	actinopterygii		Salmoniformes	Salmonidae		Oncorhynchus	Clarkii				
animalia	chordata	Actinopterygii		Salmoniformes	Salmonidae		Oncorhynchus	Mykiss				
animalia	chordata	Actinopterygii		Scorpaeniformes	Cottidae		Cottus	bairdi				
animalia	chordata	Actinopterygii		Scorpaeniformes	Cottidae		Cottus	beldingi				
animalia	chordata	Amphibia		Urodela	Ambystomatidae		Dicamptodon	Tenebrosus		x	x	x
kingdom	**phylum**	**class**	**subclass**	**order**	**family**	**subfamily**	**genus**	**species**	**L423**	**L1141**	**L1129**	**M881**
animalia	arthropoda	Insecta		Coleoptera	Dytiscidae		Oreodytes					
animalia	arthropoda	Insecta		Coleoptera	Dytiscidae							x
animalia	arthropoda	Insecta		Coleoptera	Elmidae		Ampumixis	dispar	x			
animalia	arthropoda	Insecta		Coleoptera	Elmidae		Ampumixis					
animalia	arthropoda	Insecta		Coleoptera	Elmidae		Heterlimnius					x
animalia	arthropoda	Insecta		Coleoptera	Elmidae		Lara					x
animalia	arthropoda	Insecta		Coleoptera	Elmidae		Optioservus		x			
animalia	arthropoda	Insecta		Coleoptera	Elmidae				x			x
animalia	arthropoda	Insecta		Coleoptera	Psephenidae		Acneus					
animalia	arthropoda	Insecta		Coleoptera	Ptilodactylidae		Anchycteis					
animalia	arthropoda	Insecta		Coleoptera	Staphylinidae							
animalia	arthropoda	Maxillopoda	Copepoda	Cyclopoida								
animalia	crustacea	Malacostraca		Decapoda								
animalia	arthropoda	Branchiopoda		Diplostraca	Chydoridae							
animalia	arthropoda	Insecta		Diptera	Blephariceridae				x			

kingdom	phylum	class	subclass	order	family	subfamily	genus	species	L423	L1141	L1129	M881
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae		Atrichopogon					
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae		Bezzia/Palpomyia		x			
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae		Ceratopogon					
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae		Forcipomyia					
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae		Palpomyia/Bezzia					
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae		Probezzia					
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae					x		
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae	Forcipomyiinae						x
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae	Ceratopogoninae					x	
animalia	arthropoda	Insecta		Diptera	Chironomidae	Chironominae	Chironomini					x
animalia	arthropoda	Insecta		Diptera	Chironomidae	Non-Tanypodinae						
animalia	arthropoda	Insecta		Diptera	Chironomidae	Orthocladiinae	Brillia					
animalia	arthropoda	Insecta		Diptera	Chironomidae	Orthocladiinae	Corynoneura		x			
animalia	arthropoda	Insecta		Diptera	Chironomidae	Orthocladiinae	Cricotopus		x			
animalia	arthropoda	Insecta		Diptera	Chironomidae	Orthocladiinae	Cricotopus/ Orthocladius					
animalia	arthropoda	Insecta		Diptera	Chironomidae	Orthocladiinae			x	x	x	x
animalia	arthropoda	Insecta		Diptera	Chironomidae	Tanypodinae				x	x	x
animalia	arthropoda	Insecta		Diptera	Chironomidae	Tanytarsini				x	x	x
animalia	arthropoda	Insecta		Diptera	Chironomidae				x	x	x	x
animalia	arthropoda	Insecta		Diptera	Chironomidae/ Ceratopogonidae							
animalia	arthropoda	Insecta		Diptera	Dixidae		Dixa			x	x	x
animalia	arthropoda	Insecta		Diptera	Dixidae							
animalia	arthropoda	Insecta		Diptera	Empididae		Chelifera					
animalia	arthropoda	Insecta		Diptera	Empididae		Clinocera					
animalia	arthropoda	Insecta		Diptera	Empididae		Hemerodromia					
animalia	arthropoda	Insecta		Diptera	Empididae		Metachela					
animalia	arthropoda	Insecta		Diptera	Empididae		Oreogeton					
animalia	arthropoda	Insecta		Diptera	Empididae		Oreothalia					
animalia	arthropoda	Insecta		Diptera	Empididae							
animalia	arthropoda	Insecta		Diptera	Psychodidae		Maruina					x

kingdom	phylum	class	subclass	order	family	subfamily	genus	species	L423	L1141	L1129	M881
animalia	arthropoda	Insecta		Diptera	Psychodidae		Pericoma					
animalia	arthropoda	Insecta		Diptera	Psychodidae							
animalia	arthropoda	Insecta		Diptera	Simuliidae		Prosimulium			x		
animalia	arthropoda	Insecta		Diptera	Simuliidae		Simulium		x			
animalia	arthropoda	Insecta		Diptera	Simuliidae				x			
animalia	arthropoda	Insecta		Diptera	Thaumaleidae		Thaumalea					
animalia	arthropoda	Insecta		Diptera	Thaumaleidae					x	x	
animalia	arthropoda	Insecta		Diptera	Tipulidae		Antocha					
animalia	arthropoda	Insecta		Diptera	Tipulidae		Hexatoma					
animalia	arthropoda	Insecta		Diptera	Tipulidae		Hexatoma/Limnophila					
animalia	arthropoda	Insecta		Diptera	Tipulidae		Limonia					
animalia	arthropoda	Insecta		Diptera	Tipulidae		Tipula					
animalia	arthropoda	Insecta		Diptera	Tipulidae							
animalia	arthropoda	Insecta		Ephemeroptera	Ameletidae		Ameletus			x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Baetidae		Acentrella		x			
animalia	arthropoda	Insecta		Ephemeroptera	Baetidae		Baetis	bicaudatus			x	
animalia	arthropoda	Insecta		Ephemeroptera	Baetidae		Baetis	tricaudatus	x	x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Baetidae		Baetis		x	x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Baetidae		Diphetor					
animalia	arthropoda	Insecta		Ephemeroptera	Baetidae		Heterocloeon					
animalia	arthropoda	Insecta		Ephemeroptera	Baetidae				x			
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Attenella					
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Attenella/Ephemerella/ Serratella					
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Caudatella	hystrix		x		
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Caudatella		x	x		
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Drunella	coloradensis/ flavilinea				
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Drunella	doddsii	x	x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Drunella	spinifera				x
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Drunella					
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Ephemerella					

kingdom	phylum	class	subclass	order	family	subfamily	genus	species	L423	L1141	L1129	M881
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Ephemerella/Serratella			x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Serratella					
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae				x			
animalia	arthropoda	Insecta		Ephemeroptera	Heptageniidae		Cinygma			x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Heptageniidae		Cinygmula			x		x
animalia	arthropoda	Insecta		Ephemeroptera	Heptageniidae		Epeorus	grandis			x	
animalia	arthropoda	Insecta		Ephemeroptera	Heptageniidae		Epeorus		x	x		
animalia	arthropoda	Insecta		Ephemeroptera	Heptageniidae		Ironodes		x		x	
animalia	arthropoda	Insecta		Ephemeroptera	Heptageniidae		Rhithrogena		x	x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Heptageniidae				x	x	x	
animalia	arthropoda	Insecta		Ephemeroptera	Leptophlebiidae		Paraleptophlebia			x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Leptophlebiidae							
animalia	arthropoda	Hexanauplia	Copepoda	Harpacticoida								
animalia	arthropoda	Insecta		Hemiptera	Gerridae		Gerris					
animalia	arthropoda	Insecta		Hemiptera	Veliidae		Microvelia					
animalia	Mollusca	Gastropoda		Littorinimorpha	Hydrobiidae							
animalia	arthropoda	Insecta		Megaloptera	Corydalidae		Orohermes	crepusculus				
animalia	arthropoda	Insecta		Megaloptera	Corydalidae		Orohermes					
animalia	arthropoda	Insecta		Megaloptera	Corydalidae							
animalia	arthropoda	Insecta		Megaloptera	Sialidae		Sialis					x
animalia	arthropoda	Gastropoda		Mesogastropoda	Pleuroceridae		Juga		x			
animalia	Mollusca	Gastropoda		Neotaenioglossa	Hydrobiidae		Pristinicola					
animalia	arthropoda	Insecta		Odonata	Cordulegastridae		Cordulegaster					
animalia	arthropoda	Insecta		Odonata	Gomphidae		Octogomphus					
animalia	arthropoda	Insecta		Oligochaeta						x	x	
animalia	arthropoda	Insecta		Plecoptera	Capniidae				x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Chloroperlidae		Alloperla					
animalia	arthropoda	Insecta		Plecoptera	Chloroperlidae		Kathroperla				x	
animalia	arthropoda	Insecta		Plecoptera	Chloroperlidae		Paraperla					
animalia	arthropoda	Insecta		Plecoptera	Chloroperlidae		Suwallia					
animalia	arthropoda	Insecta		Plecoptera	Chloroperlidae		Sweltsa			x	x	x

kingdom	phylum	class	subclass	order	family	subfamily	genus	species	L423	L1141	L1129	M881
animalia	arthropoda	Insecta		Plecoptera	Chloroperlidae							
animalia	arthropoda	Insecta		Plecoptera	Chloroperlidae	Chloroperlinae				x	x	x
animalia	arthropoda	Insecta		Plecoptera	Leuctridae		Despaxia			x	x	x
animalia	arthropoda	Insecta		Plecoptera	Leuctridae		Moselia			x		x
animalia	arthropoda	Insecta		Plecoptera	Leuctridae		Paraleuctra					
animalia	arthropoda	Insecta		Plecoptera	Leuctridae							
animalia	arthropoda	Insecta		Plecoptera	Leuctridae/Capniidae						x	
animalia	arthropoda	Insecta		Plecoptera	Nemouridae		Amphinemura					
animalia	arthropoda	Insecta		Plecoptera	Nemouridae		Malenka				x	
animalia	arthropoda	Insecta		Plecoptera	Nemouridae		Soyedina					
animalia	arthropoda	Insecta		Plecoptera	Nemouridae		Visoka	Cataractae				
animalia	arthropoda	Insecta		Plecoptera	Nemouridae		Visoka			x	x	x
animalia	arthropoda	Insecta		Plecoptera	Nemouridae	Nemourinae	Zapada		x	x	x	
animalia	arthropoda	Insecta		Plecoptera	Nemouridae					x	x	
animalia	arthropoda	Insecta		Plecoptera	Peltoperlidae		Soliperla			x	x	
animalia	arthropoda	Insecta		Plecoptera	Peltoperlidae		Yoraperla			x	x	x
animalia	arthropoda	Insecta		Plecoptera	Peltoperlidae							
animalia	arthropoda	Insecta		Plecoptera	Perlidae		Calineuria	californica	x			
animalia	arthropoda	Insecta		Plecoptera	Perlidae		Calineuria					x
animalia	arthropoda	Insecta		Plecoptera	Perlidae	Acroneuriinae	Doroneuria		x	x	x	
animalia	arthropoda	Insecta		Plecoptera	Perlidae		Hesperoperla					
animalia	arthropoda	Insecta		Plecoptera	Perlidae					x	x	x
animalia	arthropoda	Insecta		Plecoptera	Perlidae/Perlodidae					x	x	x
animalia	arthropoda	Insecta		Plecoptera	Perlodidae		Kogotus/Rickera					
animalia	arthropoda	Insecta		Plecoptera	Perlodidae		Megarcys					
animalia	arthropoda	Insecta		Plecoptera	Perlodidae		Skwala					
animalia	arthropoda	Insecta		Plecoptera	Perlodidae				x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Pteronarcydiae		Pteronarcys				x	x
animalia	arthropoda	Insecta		Plecoptera	Taeniopterygidae		Doddsia/Taenionema					
animalia	arthropoda	Insecta		Trichoptera	Apataniidae		Apatania			x		
animalia	arthropoda	Insecta		Trichoptera	Brachycentriade		Brachycentrus		x			

kingdom	**phylum**	**class**	**subclass**	**order**	**family**	**subfamily**	**genus**	**species**	**L423**	**L1141**	**L1129**	**M881**
animalia	arthropoda	Insecta		Trichoptera	Brachycentridae		Micrasema		x	x		x
animalia	arthropoda	Insecta		Trichoptera	Brachycentridae							x
animalia	arthropoda	Insecta		Trichoptera	Calamoceratidae		Heteroplectron	Californicum				
animalia	arthropoda	Insecta		Trichoptera	Calamoceratidae		Heteroplectron					x
animalia	arthropoda	Insecta		Trichoptera	Glossosomatidae		Anagapetus					x
animalia	arthropoda	Insecta		Trichoptera	Glossosomatidae	Glossosomatinae	Glossosoma		x			
animalia	arthropoda	Insecta		Trichoptera	Glossosomatidae				x			
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae	Arctopsychinae	Arctopsyche	grandis	x			
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae		Arctopsyche					
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae	Hydropsychinae	Ceratopsyche		x			
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae		Diplectrona					
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae		Hydropsyche					
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae		Parapsyche	elsis			x	
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae		Parapsyche			x		
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae				x			
animalia	arthropoda	Insecta		Trichoptera	Hydroptilidae		Palaeagapetus					
animalia	arthropoda	Insecta		Trichoptera	Lepidostomatidae	Lepidostomatinae	Lepidostoma			x	x	x
animalia	arthropoda	Insecta		Trichoptera	Limnephilidae		Cryptochia			x		
animalia	arthropoda	Insecta		Trichoptera	Limnephilidae		Ecclisomyia					
animalia	arthropoda	Insecta		Trichoptera	Limnephilidae		Philocasca					
animalia	arthropoda	Insecta		Trichoptera	Limnephilidae		Psychoglypha					
animalia	arthropoda	Insecta		Trichoptera	Limnephilidae					x		x
animalia	arthropoda	Insecta		Trichoptera	Odontoceridae		Namamyia					
animalia	arthropoda	Insecta		Trichoptera	Philopotamidae		Dolophilodes				x	
animalia	arthropoda	Insecta		Trichoptera	Philopotamidae		Wormaldia					
animalia	arthropoda	Insecta		Trichoptera	Philopotamidae							
animalia	arthropoda	Insecta		Trichoptera	Polycentropodidae		Polycentropus			x		
animalia	arthropoda	Insecta		Trichoptera	Rhyacophilidae		Rhyacophila		x	x	x	x
animalia	arthropoda	Insecta		Trichoptera	Uenoidae		Neophylax			x	x	x
animalia	arthropoda	Insecta		Trichoptera	Uenoidae		Neothremma					
animalia	arthropoda	Insecta		Trichoptera	Uenoidae							

kingdom	**phylum**	**class**	**subclass**	**order**	**family**	**subfamily**	**genus**	**species**	**L423**	**L1141**	**L1129**	**M881**
animalia	chordata	amphibia		urodela	Plethodontidae		Plethodon	dunni				
animalia	arthropoda	Bivalvia	Heterodonta	Veneroida	Sphaeriidae							
animalia	arthropoda	Arachnida	Acari						x	x	x	x
animalia	arthropoda	Hexanauplia	Copepoda									
animalia	cnidaria	Hydrozoa	Hydroida									
animalia	arthropoda	Gastropoda							x			
animalia	arthropoda	Insecta					Meringodixa				x	
animalia	arthropoda	Ostracoda									x	
animalia	arthropoda	Turbellaria							x	x		
protista	ochrophyta	Bacillariophyceae		Diatoms					x	x	x	x
animalia	arthropoda	CPOM/FPOM							x	x	x	x
animalia	arthropoda	Detritus							x	x	x	x
plantae	chlorophyta	Algae							x	x	x	x
animalia	chordata	amphibia		anura	ascaphidae		Ascaphus			x	x	
animalia	chordata	Actinopterygii		Cypriniformes	Cyprinidae		Rhinichthys	Cataractae	x			
animalia	chordata	Actinopterygii		Cypriniformes	Cyprinidae		Rhinichthys	Macrocheilus	x			
animalia	chordata	Actinopterygii		Cypriniformes	Cyprinidae		Rhinichthys	Osculus	x			
animalia	chordata	actinopterygii		Salmoniformes	Salmonidae		Oncorhynchus	Clarkii	x		x	
animalia	chordata	Actinopterygii		Salmoniformes	Salmonidae		Oncorhynchus	Mykiss	x			
animalia	chordata	Actinopterygii		Scorpaeniformes	Cottidae		Cottus	bairdi	x			
animalia	chordata	Actinopterygii		Scorpaeniformes	Cottidae		Cottus	beldingi	x			
animalia	chordata	Amphibia		Urodela	Ambystomatidae		Dicamptodon	Tenebrosus	x	x	x	x
kingdom	**phylum**	**class**	**subclass**	**order**	**family**	**subfamily**	**genus**	**species**	**M864**	**M734**	**R981**	**R958**
animalia	arthropoda	Insecta		Coleoptera	Dytiscidae		Oreodytes					
animalia	arthropoda	Insecta		Coleoptera	Dytiscidae							
animalia	arthropoda	Insecta		Coleoptera	Elmidae		Ampumixis	dispar				
animalia	arthropoda	Insecta		Coleoptera	Elmidae		Ampumixis			x		x
animalia	arthropoda	Insecta		Coleoptera	Elmidae		Heterlimnius		x	x	x	x
animalia	arthropoda	Insecta		Coleoptera	Elmidae		Lara		x			
animalia	arthropoda	Insecta		Coleoptera	Elmidae		Optioservus			x		
animalia	arthropoda	Insecta		Coleoptera	Elmidae				x		x	x

kingdom	phylum	class	subclass	order	family	subfamily	genus	species	M864	M734	R981	R958
animalia	arthropoda	Insecta		Coleoptera	Psephenidae		Acneus					
animalia	arthropoda	Insecta		Coleoptera	Ptilodactylidae		Anchycteis					
animalia	arthropoda	Insecta		Coleoptera	Staphylinidae							
animalia	arthropoda	Maxillopoda	Copepoda	Cyclopoida								
animalia	crustacea	Malacostraca		Decapoda								
animalia	arthropoda	Branchiopoda		Diplostraca	Chydoridae							
animalia	arthropoda	Insecta		Diptera	Blephariceridae							
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae		Atrichopogon					
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae		Bezzia/Palpomyia					
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae		Ceratopogon					
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae		Forcipomyia					
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae		Palpomyia/Bezzia					
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae		Probezzia					
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae							x
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae	Forcipomyiinae			x			
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae	Ceratopogoninae				x		x
animalia	arthropoda	Insecta		Diptera	Chironomidae	Chironominae	Chironomini					
animalia	arthropoda	Insecta		Diptera	Chironomidae	Non-Tanypodinae						
animalia	arthropoda	Insecta		Diptera	Chironomidae	Orthocladiinae	Brillia					
animalia	arthropoda	Insecta		Diptera	Chironomidae	Orthocladiinae	Corynoneura					
animalia	arthropoda	Insecta		Diptera	Chironomidae	Orthocladiinae	Cricotopus					
animalia	arthropoda	Insecta		Diptera	Chironomidae	Orthocladiinae	Cricotopus/ Orthocladius					
animalia	arthropoda	Insecta		Diptera	Chironomidae	Orthocladiinae			x	x	x	x
animalia	arthropoda	Insecta		Diptera	Chironomidae	Tanypodinae			x	x	x	x
animalia	arthropoda	Insecta		Diptera	Chironomidae	Tanytarsini			x	x	x	x
animalia	arthropoda	Insecta		Diptera	Chironomidae				x	x	x	x
animalia	arthropoda	Insecta		Diptera	Chironomidae/ Ceratopogonidae							
animalia	arthropoda	Insecta		Diptera	Dixidae		Dixa		x	x	x	x
animalia	arthropoda	Insecta		Diptera	Dixidae							x
animalia	arthropoda	Insecta		Diptera	Empididae		Chelifera					

kingdom	phylum	class	subclass	order	family	subfamily	genus	species	M864	M734	R981	R958
animalia	arthropoda	Insecta		Diptera	Empididae		Clinocera					
animalia	arthropoda	Insecta		Diptera	Empididae		Hemerodromia					
animalia	arthropoda	Insecta		Diptera	Empididae		Metachela			x		
animalia	arthropoda	Insecta		Diptera	Empididae		Oreogeton					
animalia	arthropoda	Insecta		Diptera	Empididae		Oreothalia					
animalia	arthropoda	Insecta		Diptera	Empididae							x
animalia	arthropoda	Insecta		Diptera	Psychodidae		Maruina			x		
animalia	arthropoda	Insecta		Diptera	Psychodidae		Pericoma			x		
animalia	arthropoda	Insecta		Diptera	Psychodidae							
animalia	arthropoda	Insecta		Diptera	Simuliidae		Prosimulium					
animalia	arthropoda	Insecta		Diptera	Simuliidae		Simulium		x	x	x	
animalia	arthropoda	Insecta		Diptera	Simuliidae					x		
animalia	arthropoda	Insecta		Diptera	Thaumaleidae		Thaumalea					
animalia	arthropoda	Insecta		Diptera	Thaumaleidae				x	x	x	x
animalia	arthropoda	Insecta		Diptera	Tipulidae		Antocha					
animalia	arthropoda	Insecta		Diptera	Tipulidae		Hexatoma					
animalia	arthropoda	Insecta		Diptera	Tipulidae		Hexatoma/Limnophila					
animalia	arthropoda	Insecta		Diptera	Tipulidae		Limonia					
animalia	arthropoda	Insecta		Diptera	Tipulidae		Tipula					
animalia	arthropoda	Insecta		Diptera	Tipulidae							
animalia	arthropoda	Insecta		Ephemeroptera	Ameletidae		Ameletus		x		x	x
animalia	arthropoda	Insecta		Ephemeroptera	Baetidae		Acentrella					
animalia	arthropoda	Insecta		Ephemeroptera	Baetidae		Baetis	bicaudatus				
animalia	arthropoda	Insecta		Ephemeroptera	Baetidae		Baetis	tricaudatus	x	x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Baetidae		Baetis		x	x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Baetidae		Diphetor					
animalia	arthropoda	Insecta		Ephemeroptera	Baetidae		Heterocloeon					
animalia	arthropoda	Insecta		Ephemeroptera	Baetidae							x
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Attenella					
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Attenella/Ephemerella/ Serratella					

kingdom	phylum	class	subclass	order	family	subfamily	genus	species	M864	M734	R981	R958
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Caudatella	hystrix				
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Caudatella		x	x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Drunella	coloradensis/ flavilinea			x	x
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Drunella	doddsii	x	x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Drunella	spinifera	x	x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Drunella					
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Ephemerella					
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Ephemerella/Serratella		x	x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Serratella					
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae							
animalia	arthropoda	Insecta		Ephemeroptera	Heptageniidae		Cinygma		x		x	x
animalia	arthropoda	Insecta		Ephemeroptera	Heptageniidae		Cinygmula		x	x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Heptageniidae		Epeorus	grandis	x	x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Heptageniidae		Epeorus		x	x		
animalia	arthropoda	Insecta		Ephemeroptera	Heptageniidae		Ironodes		x	x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Heptageniidae		Rhithrogena		x	x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Heptageniidae				x	x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Leptophlebiidae		Paraleptophlebia		x	x	x	x
animalia	arthropoda	Insecta		Ephemeroptera	Leptophlebiidae							
animalia	arthropoda	Hexanauplia	Copepoda	Harpacticoida								x
animalia	arthropoda	Insecta		Hemiptera	Gerridae		Gerris					
animalia	arthropoda	Insecta		Hemiptera	Veliidae		Microvelia					
animalia	Mollusca	Gastropoda		Littorinimorpha	Hydrobiidae				x			
animalia	arthropoda	Insecta		Megaloptera	Corydalidae		Orohermes	crepusculus				x
animalia	arthropoda	Insecta		Megaloptera	Corydalidae		Orohermes					
animalia	arthropoda	Insecta		Megaloptera	Corydalidae				x			
animalia	arthropoda	Insecta		Megaloptera	Sialidae		Sialis			x		
animalia	arthropoda	Gastropoda		Mesogastropoda	Pleuroceridae		Juga					
animalia	Mollusca	Gastropoda		Neotaenioglossa	Hydrobiidae		Pristinicola					x
animalia	arthropoda	Insecta		Odonata	Cordulegastridae		Cordulegaster					

kingdom	phylum	class	subclass	order	family	subfamily	genus	species	M864	M734	R981	R958
animalia	arthropoda	Insecta		Odonata		Gomphidae	Octogomphus					
animalia	arthropoda	Insecta		Oligochaeta					x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Capniidae						x	x
animalia	arthropoda	Insecta		Plecoptera	Chloroperlidae		Alloperla					
animalia	arthropoda	Insecta		Plecoptera	Chloroperlidae		Kathroperla		x			
animalia	arthropoda	Insecta		Plecoptera	Chloroperlidae		Paraperla					
animalia	arthropoda	Insecta		Plecoptera	Chloroperlidae		Suwallia					
animalia	arthropoda	Insecta		Plecoptera	Chloroperlidae		Sweltsa		x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Chloroperlidae							
animalia	arthropoda	Insecta		Plecoptera	Chloroperlidae	Chloroperlinae			x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Leuctridae		Despaxia		x		x	x
animalia	arthropoda	Insecta		Plecoptera	Leuctridae		Moselia					x
animalia	arthropoda	Insecta		Plecoptera	Leuctridae		Paraleuctra		x			
animalia	arthropoda	Insecta		Plecoptera	Leuctridae					x	x	x
animalia	arthropoda	Insecta		Plecoptera	Leuctridae/Capniidae							
animalia	arthropoda	Insecta		Plecoptera	Nemouridae		Amphinemura					
animalia	arthropoda	Insecta		Plecoptera	Nemouridae		Malenka				x	
animalia	arthropoda	Insecta		Plecoptera	Nemouridae		Soyedina					
animalia	arthropoda	Insecta		Plecoptera	Nemouridae		Visoka	Cataractae				
animalia	arthropoda	Insecta		Plecoptera	Nemouridae		Visoka		x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Nemouridae	Nemourinae	Zapada		x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Nemouridae				x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Peltoperlidae		Soliperla		x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Peltoperlidae		Yoraperla		x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Peltoperlidae					x		
animalia	arthropoda	Insecta		Plecoptera	Perlidae		Calineuria	californica				
animalia	arthropoda	Insecta		Plecoptera	Perlidae		Calineuria		x	x		
animalia	arthropoda	Insecta		Plecoptera	Perlidae	Acroneuriinae	Doroneuria		x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Perlidae		Hesperoperla					
animalia	arthropoda	Insecta		Plecoptera	Perlidae				x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Perlidae/Perlodidae				x	x	x	x

kingdom	phylum	class	subclass	order	family	subfamily	genus	species	M864	M734	R981	R958
animalia	arthropoda	Insecta		Plecoptera	Perlodidae		Kogotus/Rickera					
animalia	arthropoda	Insecta		Plecoptera	Perlodidae		Megarcys		x	x	x	x
animalia	arthropoda	Insecta		Plecoptera	Perlodidae		Skwala			x		
animalia	arthropoda	Insecta		Plecoptera	Perlodidae					x	x	
animalia	arthropoda	Insecta		Plecoptera	Pteronarcydiae		Pteronarcys		x		x	x
animalia	arthropoda	Insecta		Plecoptera	Taeniopterygidae		Doddsia/Taenionema					
animalia	arthropoda	Insecta		Trichoptera	Apataniidae		Apatania			x	x	
animalia	arthropoda	Insecta		Trichoptera	Brachycentriade		Brachycentrus					
animalia	arthropoda	Insecta		Trichoptera	Brachycentridae		Micrasema		x	x	x	x
animalia	arthropoda	Insecta		Trichoptera	Brachycentridae				x	x		
animalia	arthropoda	Insecta		Trichoptera	Calamoceratidae		Heteroplectron	Californicum				
animalia	arthropoda	Insecta		Trichoptera	Calamoceratidae		Heteroplectron			x		
animalia	arthropoda	Insecta		Trichoptera	Glossosomatidae		Anagapetus		x	x	x	x
animalia	arthropoda	Insecta		Trichoptera	Glossosomatidae	Glossosomatinae	Glossosoma		x		x	
animalia	arthropoda	Insecta		Trichoptera	Glossosomatidae				x	x	x	x
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae	Arctopsychinae	Arctopsyche	grandis				
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae		Arctopsyche			x		
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae	Hydropsychinae	Ceratopsyche					
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae		Diplectrona					
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae		Hydropsyche			x		
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae		Parapsyche	elsis				
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae		Parapsyche		x	x	x	x
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae				x	x		x
animalia	arthropoda	Insecta		Trichoptera	Hydroptilidae		Palaeagapetus					
animalia	arthropoda	Insecta		Trichoptera	Lepidostomatidae	Lepidostomatinae	Lepidostoma		x	x		x
animalia	arthropoda	Insecta		Trichoptera	Limnephilidae		Cryptochia					
animalia	arthropoda	Insecta		Trichoptera	Limnephilidae		Ecclisomyia					
animalia	arthropoda	Insecta		Trichoptera	Limnephilidae		Philocasca					
animalia	arthropoda	Insecta		Trichoptera	Limnephilidae		Psychoglypha					
animalia	arthropoda	Insecta		Trichoptera	Limnephilidae				x			
animalia	arthropoda	Insecta		Trichoptera	Odontoceridae		Namamyia					

kingdom	phylum	class	subclass	order	family	subfamily	genus	species	M864	M734	R981	R958
animalia	arthropoda	Insecta		Trichoptera	Philopotamidae		Dolophilodes		x	x		x
animalia	arthropoda	Insecta		Trichoptera	Philopotamidae		Wormaldia					
animalia	arthropoda	Insecta		Trichoptera	Philopotamidae							
animalia	arthropoda	Insecta		Trichoptera	Polycentropodidae		Polycentropus				x	
animalia	arthropoda	Insecta		Trichoptera	Rhyacophilidae		Rhyacophila		x	x	x	x
animalia	arthropoda	Insecta		Trichoptera	Uenoidae		Neophylax		x	x	x	
animalia	arthropoda	Insecta		Trichoptera	Uenoidae		Neothremma					
animalia	arthropoda	Insecta		Trichoptera	Uenoidae							
animalia	chordata	amphibia		urodela	Plethodontidae		Plethodon	dunni				
animalia	arthropoda	Bivalvia	Heterodonta	Veneroida	Sphaeriidae							
animalia	arthropoda	Arachnida	Acari						x	x	x	x
animalia	arthropoda	Hexanauplia	Copepoda									
animalia	cnidaria	Hydrozoa	Hydroida									
animalia	arthropoda	Gastropoda										
animalia	arthropoda	Insecta					Meringodixa					
animalia	arthropoda	Ostracoda							x	x	x	x
animalia	arthropoda	Turbellaria									x	x
protista	ochrophyta	Bacillariophyceae		Diatoms					x	x	x	x
animalia	arthropoda	CPOM/FPOM							x	x	x	x
animalia	arthropoda	Detritus							x	x	x	x
plantae	chlorophyta	Algae							x	x	x	x
animalia	chordata	amphibia		anura	ascaphidae		Ascaphus			x		
animalia	chordata	Actinopterygii		Cypriniformes	Cyprinidae		Rhinichthys	Cataractae				
animalia	chordata	Actinopterygii		Cypriniformes	Cyprinidae		Rhinichthys	Macrocheilus				
animalia	chordata	Actinopterygii		Cypriniformes	Cyprinidae		Rhinichthys	Osculus				
animalia	chordata	actinopterygii		Salmoniformes	Salmonidae		Oncorhynchus	Clarkii	x	x		x
animalia	chordata	Actinopterygii		Salmoniformes	Salmonidae		Oncorhynchus	Mykiss				
animalia	chordata	Actinopterygii		Scorpaeniformes	Cottidae		Cottus	bairdi				
animalia	chordata	Actinopterygii		Scorpaeniformes	Cottidae		Cottus	beldingi				
animalia	chordata	Amphibia		Urodela	Ambystomatidae		Dicamptodon	Tenebrosus	x	x	x	x
animalia	arthropoda	Insecta		Coleoptera	Dytiscidae		Oreodytes			x		

kingdom	phylum	class	subclass	order	family	subfamily	genus	species	R870	R558
animalia	arthropoda	Insecta		Coleoptera	Dytiscidae					
animalia	arthropoda	Insecta		Coleoptera	Elmidae		Ampumixis	dispar	x	
animalia	arthropoda	Insecta		Coleoptera	Elmidae		Ampumixis			x
animalia	arthropoda	Insecta		Coleoptera	Elmidae		Heterlimnius		x	x
animalia	arthropoda	Insecta		Coleoptera	Elmidae		Lara		x	x
animalia	arthropoda	Insecta		Coleoptera	Elmidae		Optioservus			
animalia	arthropoda	Insecta		Coleoptera	Elmidae				x	x
animalia	arthropoda	Insecta		Coleoptera	Psephenidae		Acneus			
animalia	arthropoda	Insecta		Coleoptera	Ptilodactylidae		Anchycteis			
animalia	arthropoda	Insecta		Coleoptera	Staphylinidae					
animalia	arthropoda	Maxillopoda	Copepoda	Cyclopoida						x
animalia	crustacea	Malacostraca		Decapoda						x
animalia	arthropoda	Branchiopoda		Diplostraca	Chydoridae					
animalia	arthropoda	Insecta		Diptera	Blephariceridae					
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae		Atrichopogon			
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae		Bezzia/Palpomyia			
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae		Ceratopogon			
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae		Forcipomyia			
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae		Palpomyia/Bezzia			x
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae		Probezzia			
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae				x	x
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae	Forcipomyiinae				
animalia	arthropoda	Insecta		Diptera	Ceratopogonidae	Ceratopogoninae				
animalia	arthropoda	Insecta		Diptera	Chironomidae	Chironominae	Chironomini		x	
animalia	arthropoda	Insecta		Diptera	Chironomidae	Non-Tanypodinae				x
animalia	arthropoda	Insecta		Diptera	Chironomidae	Orthocladiinae	Brillia		x	
animalia	arthropoda	Insecta		Diptera	Chironomidae	Orthocladiinae	Corynoneura		x	
animalia	arthropoda	Insecta		Diptera	Chironomidae	Orthocladiinae	Cricotopus			
animalia	arthropoda	Insecta		Diptera	Chironomidae	Orthocladiinae	Cricotopus/ Orthocladius		x	
animalia	arthropoda	Insecta		Diptera	Chironomidae	Orthocladiinae			x	
animalia	arthropoda	Insecta		Diptera	Chironomidae	Tanypodinae			x	x

kingdom	phylum	class	subclass	order	family	subfamily	genus	species	R870	R558
animalia	arthropoda	Insecta		Diptera	Chironomidae	Tanytarsini			x	
animalia	arthropoda	Insecta		Diptera	Chironomidae				x	x
animalia	arthropoda	Insecta		Diptera	Chironomidae/ Ceratopogonidae					
animalia	arthropoda	Insecta		Diptera	Dixidae		Dixa		x	
animalia	arthropoda	Insecta		Diptera	Dixidae					
animalia	arthropoda	Insecta		Diptera	Empididae		Chelifera			
animalia	arthropoda	Insecta		Diptera	Empididae		Clinocera			x
animalia	arthropoda	Insecta		Diptera	Empididae		Hemerodromia			
animalia	arthropoda	Insecta		Diptera	Empididae		Metachela			x
animalia	arthropoda	Insecta		Diptera	Empididae		Oreogeton		x	x
animalia	arthropoda	Insecta		Diptera	Empididae		Oreothalia			
animalia	arthropoda	Insecta		Diptera	Empididae				x	x
animalia	arthropoda	Insecta		Diptera	Psychodidae		Maruina			
animalia	arthropoda	Insecta		Diptera	Psychodidae		Pericoma			
animalia	arthropoda	Insecta		Diptera	Psychodidae					
animalia	arthropoda	Insecta		Diptera	Simuliidae		Prosimulium			
animalia	arthropoda	Insecta		Diptera	Simuliidae		Simulium		x	
animalia	arthropoda	Insecta		Diptera	Simuliidae				x	
animalia	arthropoda	Insecta		Diptera	Thaumaleidae		Thaumalea			
animalia	arthropoda	Insecta		Diptera	Thaumaleidae					
animalia	arthropoda	Insecta		Diptera	Tipulidae		Antocha			
animalia	arthropoda	Insecta		Diptera	Tipulidae		Hexatoma		x	x
animalia	arthropoda	Insecta		Diptera	Tipulidae		Hexatoma/Limnophila			
animalia	arthropoda	Insecta		Diptera	Tipulidae		Limonia			x
animalia	arthropoda	Insecta		Diptera	Tipulidae		Tipula		x	
animalia	arthropoda	Insecta		Diptera	Tipulidae					x
animalia	arthropoda	Insecta		Ephemeroptera	Ameletidae		Ameletus		x	x
animalia	arthropoda	Insecta		Ephemeroptera	Baetidae		Acentrella			
animalia	arthropoda	Insecta		Ephemeroptera	Baetidae		Baetis	bicaudatus		
animalia	arthropoda	Insecta		Ephemeroptera	Baetidae		Baetis	tricaudatus	x	
animalia	arthropoda	Insecta		Ephemeroptera	Baetidae		Baetis		x	x

kingdom	phylum	class	subclass	order	family	subfamily	genus	species	R870	R558
animalia	arthropoda	Insecta		Ephemeroptera	Baetidae		Diphetor			
animalia	arthropoda	Insecta		Ephemeroptera	Baetidae		Heterocloeon			x
animalia	arthropoda	Insecta		Ephemeroptera	Baetidae					x
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Attenella			x
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Attenella/Ephemerella/ Serratella			
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Caudatella	hystrix		
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Caudatella		x	
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Drunella	coloradensis/ flavilinea		
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Drunella	doddsii	x	
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Drunella	spinifera	x	
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Drunella			
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Ephemerella		x	
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Ephemerella/Serratella			
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae		Serratella			x
animalia	arthropoda	Insecta		Ephemeroptera	Ephemerellidae				x	x
animalia	arthropoda	Insecta		Ephemeroptera	Heptageniidae		Cinygma			
animalia	arthropoda	Insecta		Ephemeroptera	Heptageniidae		Cinygmula		x	x
animalia	arthropoda	Insecta		Ephemeroptera	Heptageniidae		Epeorus	grandis		
animalia	arthropoda	Insecta		Ephemeroptera	Heptageniidae		Epeorus		x	
animalia	arthropoda	Insecta		Ephemeroptera	Heptageniidae		Ironodes		x	x
animalia	arthropoda	Insecta		Ephemeroptera	Heptageniidae		Rhithrogena		x	x
animalia	arthropoda	Insecta		Ephemeroptera	Heptageniidae				x	x
animalia	arthropoda	Insecta		Ephemeroptera	Leptophlebiidae		Paraleptophlebia		x	x
animalia	arthropoda	Insecta		Ephemeroptera	Leptophlebiidae					x
animalia	arthropoda	Hexanauplia	Copepoda	Harpacticoida						
animalia	arthropoda	Insecta		Hemiptera	Gerridae		Gerris			
animalia	arthropoda	Insecta		Hemiptera	Veliidae		Microvelia			x
animalia	Mollusca	Gastropoda		Littorinimorpha	Hydrobiidae					
animalia	arthropoda	Insecta		Megaloptera	Corydalidae		Orohermes	crepusculus		
animalia	arthropoda	Insecta		Megaloptera	Corydalidae		Orohermes			

kingdom	phylum	class	subclass	order	family	subfamily	genus	species	R870	R558
animalia	arthropoda	Insecta		Megaloptera	Corydalidae					
animalia	arthropoda	Insecta		Megaloptera	Sialidae		Sialis		x	
animalia	arthropoda	Gastropoda		Mesogastropoda	Pleuroceridae		Juga			
animalia	Mollusca	Gastropoda		Neotaenioglossa	Hydrobiidae		Pristinicola			
animalia	arthropoda	Insecta		Odonata	Cordulegastridae		Cordulegaster			
animalia	arthropoda	Insecta		Odonata	Gomphidae		Octogomphus			x
animalia	arthropoda	Insecta		Oligochaeta					x	x
animalia	arthropoda	Insecta		Plecoptera	Capniidae				x	x
animalia	arthropoda	Insecta		Plecoptera	Chloroperlidae		Alloperla			
animalia	arthropoda	Insecta		Plecoptera	Chloroperlidae		Kathroperla		x	
animalia	arthropoda	Insecta		Plecoptera	Chloroperlidae		Paraperla			x
animalia	arthropoda	Insecta		Plecoptera	Chloroperlidae		Suwallia			
animalia	arthropoda	Insecta		Plecoptera	Chloroperlidae		Sweltsa		x	x
animalia	arthropoda	Insecta		Plecoptera	Chloroperlidae				x	x
animalia	arthropoda	Insecta		Plecoptera	Chloroperlidae	Chloroperlinae				
animalia	arthropoda	Insecta		Plecoptera	Leuctridae		Despaxia			x
animalia	arthropoda	Insecta		Plecoptera	Leuctridae		Moselia			
animalia	arthropoda	Insecta		Plecoptera	Leuctridae		Paraleuctra			
animalia	arthropoda	Insecta		Plecoptera	Leuctridae				x	x
animalia	arthropoda	Insecta		Plecoptera	Leuctridae/Capniidae					
animalia	arthropoda	Insecta		Plecoptera	Nemouridae		Amphinemura			x
animalia	arthropoda	Insecta		Plecoptera	Nemouridae		Malenka			
animalia	arthropoda	Insecta		Plecoptera	Nemouridae		Soyedina			
animalia	arthropoda	Insecta		Plecoptera	Nemouridae		Visoka	Cataractae	x	
animalia	arthropoda	Insecta		Plecoptera	Nemouridae		Visoka			
animalia	arthropoda	Insecta		Plecoptera	Nemouridae	Nemourinae	Zapada		x	x
animalia	arthropoda	Insecta		Plecoptera	Nemouridae					
animalia	arthropoda	Insecta		Plecoptera	Peltoperlidae		Soliperla			
animalia	arthropoda	Insecta		Plecoptera	Peltoperlidae		Yoraperla		x	
animalia	arthropoda	Insecta		Plecoptera	Peltoperlidae					
animalia	arthropoda	Insecta		Plecoptera	Perlidae		Calineuria	californica	x	x

kingdom	phylum	class	subclass	order	family	subfamily	genus	species	R870	R558
animalia	arthropoda	Insecta		Plecoptera	Perlidae		Calineuria			
animalia	arthropoda	Insecta		Plecoptera	Perlidae	Acroneuriinae	Doroneuria		x	
animalia	arthropoda	Insecta		Plecoptera	Perlidae		Hesperoperla			x
animalia	arthropoda	Insecta		Plecoptera	Perlidae				x	x
animalia	arthropoda	Insecta		Plecoptera	Perlidae/Perlodidae					
animalia	arthropoda	Insecta		Plecoptera	Perlodidae		Kogotus/Rickera			
animalia	arthropoda	Insecta		Plecoptera	Perlodidae		Megarcys		x	
animalia	arthropoda	Insecta		Plecoptera	Perlodidae		Skwala			x
animalia	arthropoda	Insecta		Plecoptera	Perlodidae				x	x
animalia	arthropoda	Insecta		Plecoptera	Pteronarcydiae		Pteronarcys		x	
animalia	arthropoda	Insecta		Plecoptera	Taeniopterygidae		Doddsia/Taenionema			
animalia	arthropoda	Insecta		Trichoptera	Apataniidae		Apatania			
animalia	arthropoda	Insecta		Trichoptera	Brachycentriade		Brachycentrus			
animalia	arthropoda	Insecta		Trichoptera	Brachycentridae		Micrasema		x	x
animalia	arthropoda	Insecta		Trichoptera	Brachycentridae					
animalia	arthropoda	Insecta		Trichoptera	Calamoceratidae		Heteroplectron	Californicum	x	
animalia	arthropoda	Insecta		Trichoptera	Calamoceratidae		Heteroplectron			
animalia	arthropoda	Insecta		Trichoptera	Glossosomatidae		Anagapetus			
animalia	arthropoda	Insecta		Trichoptera	Glossosomatidae	Glossosomatinae	Glossosoma		x	x
animalia	arthropoda	Insecta		Trichoptera	Glossosomatidae				x	
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae	Arctopsychinae	Arctopsyche	grandis		
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae		Arctopsyche			
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae	Hydropsychinae	Ceratopsyche			
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae		Diplectrona			x
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae		Hydropsyche			x
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae		Parapsyche	elsis		
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae		Parapsyche		x	
animalia	arthropoda	Insecta		Trichoptera	Hydropsychidae				x	x
animalia	arthropoda	Insecta		Trichoptera	Hydroptilidae		Palaeagapetus			
animalia	arthropoda	Insecta		Trichoptera	Lepidostomatidae	Lepidostomatinae	Lepidostoma		x	x
animalia	arthropoda	Insecta		Trichoptera	Limnephilidae		Cryptochia			

kingdom	phylum	class	subclass	order	family	subfamily	genus	species	R870	R558
animalia	arthropoda	Insecta		Trichoptera	Limnephilidae		Ecclisomyia			
animalia	arthropoda	Insecta		Trichoptera	Limnephilidae		Philocasca			
animalia	arthropoda	Insecta		Trichoptera	Limnephilidae		Psychoglypha			x
animalia	arthropoda	Insecta		Trichoptera	Limnephilidae				x	
animalia	arthropoda	Insecta		Trichoptera	Odontoceridae		Namamyia			
animalia	arthropoda	Insecta		Trichoptera	Philopotamidae		Dolophilodes		x	
animalia	arthropoda	Insecta		Trichoptera	Philopotamidae		Wormaldia			x
animalia	arthropoda	Insecta		Trichoptera	Philopotamidae					
animalia	arthropoda	Insecta		Trichoptera	Polycentropodidae		Polycentropus		x	x
animalia	arthropoda	Insecta		Trichoptera	Rhyacophilidae		Rhyacophila		x	x
animalia	arthropoda	Insecta		Trichoptera	Uenoidae		Neophylax		x	
animalia	arthropoda	Insecta		Trichoptera	Uenoidae		Neothremma			
animalia	arthropoda	Insecta		Trichoptera	Uenoidae					
animalia	chordata	amphibia		urodela	Plethodontidae		Plethodon	dunni		x
animalia	arthropoda	Bivalvia	Heterodonta	Veneroida	Sphaeriidae					
animalia	arthropoda	Arachnida	Acari						x	x
animalia	arthropoda	Hexanauplia	Copepoda							
animalia	cnidaria	Hydrozoa	Hydroida							
animalia	arthropoda	Gastropoda							x	
animalia	arthropoda	Insecta					Meringodixa			
animalia	arthropoda	Ostracoda								
animalia	arthropoda	Turbellaria							x	x
protista	ochrophyta	Bacillariophyceae		Diatoms					x	x
animalia	arthropoda	CPOM/FPOM							x	x
animalia	arthropoda	Detritus							x	x
plantae	chlorophyta	Algae							x	x
animalia	chordata	amphibia		anura	ascaphidae		Ascaphus		x	x
animalia	chordata	Actinopterygii		Cypriniformes	Cyprinidae		Rhinichthys	Cataractae		
animalia	chordata	Actinopterygii		Cypriniformes	Cyprinidae		Rhinichthys	Macrocheilus		
animalia	chordata	Actinopterygii		Cypriniformes	Cyprinidae		Rhinichthys	Osculus		
animalia	chordata	actinopterygii		Salmoniformes	Salmonidae		Oncorhynchus	Clarkii	x	x

kingdom	phylum	class	subclass	order	family	subfamily	genus	species	R870	R558
animalia	chordata	Actinopterygii		Salmoniformes	Salmonidae		Oncorhynchus	Mykiss		
animalia	chordata	Actinopterygii		Scorpaeniformes	Cottidae		Cottus	bairdi		
animalia	chordata	Actinopterygii		Scorpaeniformes	Cottidae		Cottus	beldingi		x
animalia	chordata	Amphibia		Urodela	Ambystomatidae		Dicamptodon	Tenebrosus	x	x

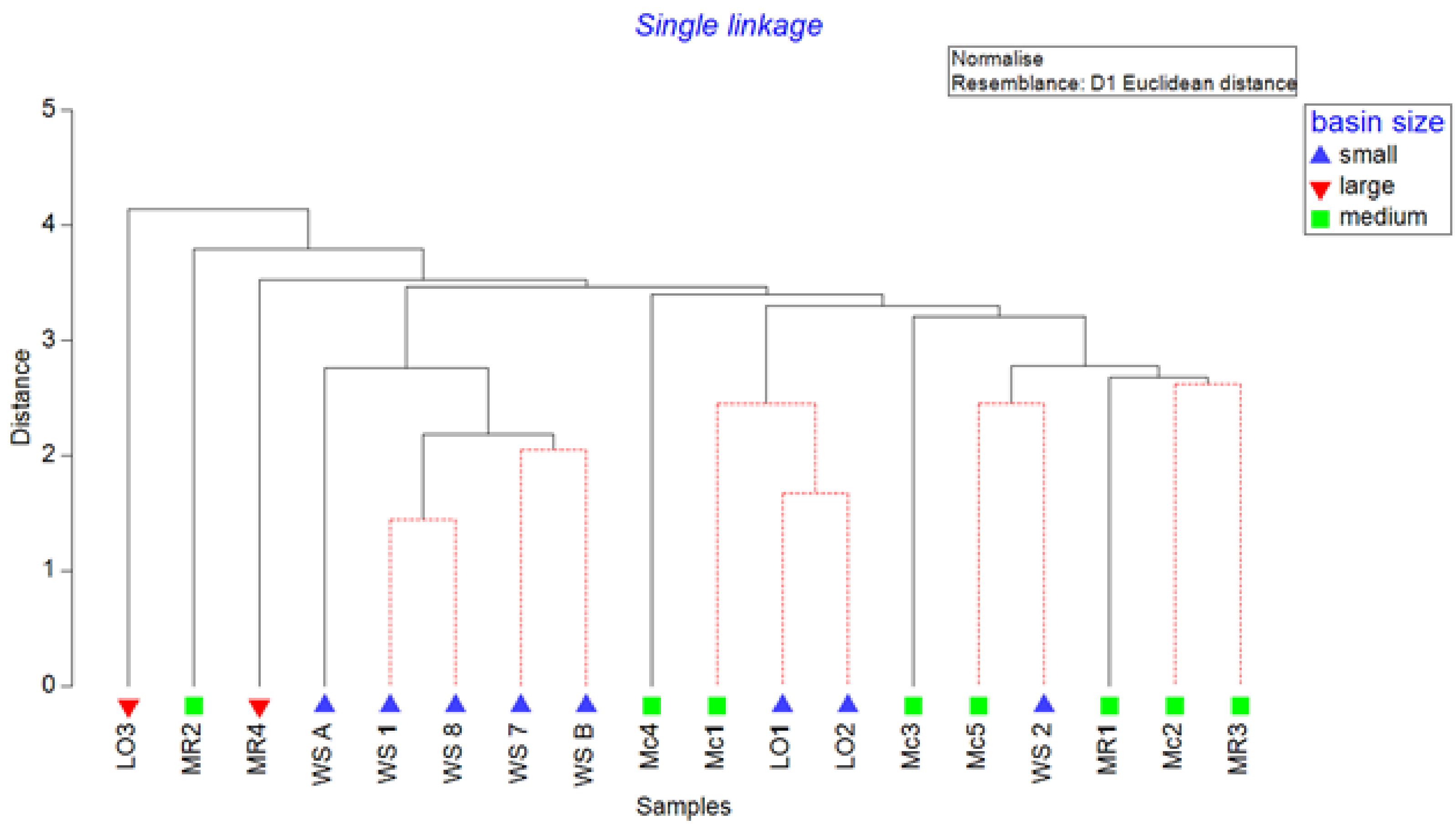
Appendix B. Table of geophysical variables used to test relationships between food web structures and surrounding landscape.

Site ID	Elevation (m)	Stream Length (km)	Drainage Area (km^2)	Network Density[1]	Average Canopy Cover (%)[2]	Sinuosity[3]	Gradient[4]
L1141	1141	1.68	0.92	1.07	75.87	1.117	15.01
L1129	1129	1.81	1.09	0.9	75.94	1.006	12.06
L423	423	232.14	62.06	1.92	78.94	1.013	2.24
R981	981	9.1	3.74	1.29	74.96	1.01	21.22
R958	958	9.21	3.80	1.27	75.05	1.011	17.74
R870	870	12.61	4.90	1.32	73.79	1.016	12.08
R558	558	13.48	5.28	1.31	74.32	1.07	10.17
M881	881	14.38	5.37	1.38	74.47	1.03	7.5
M864	864	12.3	2.93	2.15	76.64	1.085	11.75
M770	770	13.06	3.13	2.14	77.5	1.039	16.06
M764	764	33.02	7.56	2.24	78.11	1.104	26.95
M734	734	68.3	15.30	2.29	81.7	1.003	3.41
RT_690_WS7	690	0.82	0.21	1.97	79.23	1.004	16.28
RT_690_WS8	690	1.39	0.27	2.69	79.37	1.009	14.55
L643_NBW	643	1.56	0.46	1.74	78.05	1.006	27.53
L624_AW	624	1.27	0.50	1.32	78.08	1.041	17.78
L415_WS1	415	3.17	0.96	1.7	77.87	1.015	23.71
L432_WS2	432	3.18	0.64	2.57	83.78	1.018	11.5

[1]Stream length divided by basin area. [2]Average canopy cover per basin area. [3]Sinuosity of stream reach 50m above food web site. [4]Gradient of stream reach 50m above food web site.

Appendix C. Values of 16 structural metrics calculated for each site/food web. *O*: proportion of taxa in each web that feed from more than one trophic level. APL: average path length. *Co*: connectance.

Site Name	Max trophic position	Prey: Predator ratio	Number of nodes	Number of links	*O*	Fraction bottom nodes	Fraction middle nodes	Fraction top-level nodes	Fraction non-top level nodes	Fraction cannibalistic	APL	Linkage density	*Co*	Sum diet gaps	Sum consumer gaps	Mean max trophic similarity
L1141	3.54	1.06	53	463	0.34	0.08	0.89	0.04	0.96	0.21	1.68	8.74	0.16	679	1304	0.83
L1129	3.58	1.04	52	437	0.35	0.08	0.89	0.04	0.96	0.17	1.71	8.40	0.16	673	1501	0.81
L423	4.53	0.96	50	473	0.48	0.08	0.92	0.00	1.00	0.16	1.62	9.46	0.19	812	1474	0.80
M881	3.40	1.07	49	382	0.37	0.08	0.88	0.04	0.96	0.12	1.67	7.79	0.16	609	1047	0.85
M864	3.46	1.03	65	664	0.35	0.06	0.94	0.00	1.00	0.12	1.68	10.22	0.16	1152	2567	0.85
M770	5.33	0.97	73	926	0.47	0.05	0.95	0.00	1.00	0.26	1.66	12.68	0.17	1633	3263	0.83
M764	4.00	0.97	79	1159	0.51	0.05	0.94	0.01	0.99	0.24	1.65	14.67	0.19	2118	3948	0.84
M734	4.33	1.02	70	855	0.39	0.06	0.94	0.00	1.00	0.19	1.64	12.21	0.17	1372	3066	0.86
R981	3.53	0.98	59	557	0.37	0.07	0.92	0.02	0.98	0.15	1.67	9.44	0.16	966	1780	0.84
R958	5.24	0.81	66	707	0.41	0.06	0.94	0.00	1.00	0.18	1.68	10.71	0.16	1370	2690	0.85
R870	3.60	1.02	73	842	0.38	0.05	0.95	0.00	1.00	0.16	1.68	11.53	0.16	1370	3443	0.82
R558	5.13	0.86	69	972	0.57	0.06	0.93	0.01	0.99	0.25	1.61	14.09	0.20	1592	2884	0.84
L415_WS1	3.83	1.00	69	629	0.36	0.06	0.91	0.03	0.97	0.23	1.75	9.12	0.13	1212	2920	0.82
L432_WS2	4.11	1.00	68	797	0.40	0.06	0.93	0.01	0.99	0.25	1.65	11.72	0.17	1150	2913	0.87
RT_690_WS7	3.45	1.04	78	882	0.35	0.05	0.91	0.04	0.96	0.18	1.74	11.31	0.15	1455	2942	0.85
RT_690_WS8	3.40	1.05	70	682	0.39	0.06	0.91	0.03	0.97	0.23	1.73	9.74	0.14	1294	2563	0.83
L643_NBW	3.48	1.04	84	894	0.36	0.05	0.93	0.02	0.98	0.20	1.76	10.64	0.13	1891	3784	0.87
L624_AW	3.58	1.04	75	756	0.39	0.05	0.92	0.03	0.97	0.16	1.75	10.08	0.13	1514	3412	0.85



Appendix D. Clustering analysis of food web structures based on Euclidean distance. Red dashed lines in the dendrogram show no differences in structure detected by the SIMPROF test (i.e. have a p-value of <0.05 and are considered structurally highly similar).

Appendix E: Individual correlations between food web metrics and the geophysical variables. Drainage area and stream length are colinear, so only drainage area was chosen to be discussed due to its prevalence in existing research. All significant correlations are bold and denoted by *.

Metric	Statistic	Elevation (m)	Stream Length (km)	Drainage Area (km^2)	Network Density	Average Canopy Cover (%)	Sinuosity	Gradient (%)
Max trophic position	Pearson rho	-0.225	0.35	0.34	0.157	0.0662	-0.186	-0.515
	P-value	0.37	0.154	0.167	0.533	0.794	0.461	**0.0286***
Prey:Predator ratio	Pearson rho	0.141	-0.315	-0.284	-0.371	-0.227	0.0493	0.407
	P-value	0.577	0.203	0.254	0.129	0.365	0.846	0.0933
Nodes	Pearson rho	-0.368	-0.368	-0.38	0.199	0.145	-0.0341	0.235
	P-value	0.133	0.133	0.12	0.429	0.565	0.893	0.347
Number of links	Pearson rho	-0.343	-0.179	-0.189	0.18	0.105	0.0153	-0.112
	P-value	0.163	0.478	0.452	0.474	0.678	0.952	0.657
Fraction omnivorous	Pearson rho	-0.391	0.512	0.495	0.238	0.17	-0.141	-0.593
	P-value	0.108	**0.0298***	**0.0367***	0.343	0.499	0.578	**0.00948***
Fraction bottom nodes	Pearson rho	0.363	0.394	0.409	-0.262	-0.17	0.0346	-0.227
	P-value	0.139	0.106	0.0921	0.293	0.499	0.891	0.365
Fraction middle nodes	Pearson rho	-0.321	0.0924	0.0883	0.285	0.0251	0.0631	-0.102
	P-value	0.194	0.715	0.728	0.252	0.921	0.804	0.688
Fraction top-level nodes	Pearson rho	0.185	-0.39	-0.394	-0.204	0.081	-0.107	0.289
	P-value	0.461	0.11	0.105	0.417	0.749	0.671	0.245
Fraction non-top level nodes	Pearson rho	-0.185	0.39	0.395	0.204	-0.0804	0.107	-0.29
	P-value	0.462	0.11	0.105	0.417	0.751	0.672	0.243
Fraction cannibalistic	Pearson rho	-0.386	-0.129	-0.144	0.222	0.3	-0.0241	-0.319
	P-value	0.113	0.609	0.569	0.376	0.227	0.924	0.196
APL	Pearson rho	0.0226	-0.518	-0.519	-0.0927	0.0117	-0.124	0.703
	P-value	0.929	**0.0277***	**0.0274***	0.714	0.963	0.625	**0.00115***
Linkage density	Pearson rho	-0.307	0.00868	-0.00368	0.2	0.113	0.0302	-0.364
	P-value	0.215	0.973	0.988	0.426	0.655	0.905	0.137
Co	Pearson rho	-0.0223	0.514	0.51	0.0364	0.0206	0.0591	-0.768
	P-value	0.93	**0.0292***	**0.0305***	0.886	0.935	0.816	**0.000198***
Sum diet gaps	Pearson rho	-0.349	-0.193	-0.201	0.123	0.0327	-0.0162	0.0144
	P-value	0.156	0.442	0.425	0.626	0.897	0.949	0.955
Sum consumer gaps	Pearson rho	-0.403	-0.274	-0.283	0.172	0.11	-0.0109	0.202
	P-value	0.0972	0.272	0.256	0.496	0.665	0.966	0.421
Mean max trophic similarity	Pearson rho	-0.13	-0.516	-0.517	0.0934	0.192	-0.0687	0.0366
	P-value	0.607	**0.0282***	**0.0279***	0.712	0.445	0.787	0.885

Appendix F. Pearson correlation rho and p-values for correlations between fraction of omnivory and values of individual structural metrics of each food web. Significant correlations were found between *O* and maximum trophic position (Max TP), prey:predator ratios, number of links, APL, linkage density, and *Co.* All significant p-values are bold and denoted by *.

Fraction omnivorous versus …	Max trophic position	Prey: Predator ratio	Number of links	Number of nodes	Fraction bottom nodes	Fraction middle nodes	Fraction top-level nodes	Fraction non-top level nodes	Fraction cannibalistic	APL	Linkage density	*Co*	Sum diet gaps	Sum consumer gaps	Mean max trophic similarity
Pearson rho	0.718	-0.654	0.506	0.135	-0.142	0.414	-0.458	0.459	0.472	-0.664	0.707	0.763	0.437	0.262	-0.154
p-value	**0.001***	**0.003***	**0.032***	0.592	0.573	0.088	0.056	0.055	0.048	**0.003***	**0.001***	**0.000***	0.070	0.293	0.543