# Functional diversity and trophic relationships in benthic communities : a multi-scale spatial approach in neotropical savanna streams

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# Diversité fonctionnelle et relations trophiques dans les communautés benthiques : une approche spatiale multi-échelle dans les cours d'eau de savane néotropicale

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Ph.D Thesis

# FUNCTIONAL DIVERSITY AND TROPHIC RELATIONSHIPS IN BENTHIC COMMUNITIES: A MULTI-SCALE SPATIAL APPROACH IN NEOTROPICAL SAVANNA STREAMS

DIEGO MARCEL PARREIRA DE CASTRO

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Thesis presented in co-supervision to obtain the degree of Doctor as a co-tutelage program between the Postgraduate Program in Ecology, Conservation, and Management of Wildlife (Universidade Federal de Minas Gerais, Brazil) and the Ecole Doctorale E2M2 (Université Claude Bernard Lyon 1, France).


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*“The love for all living creatures is the most noble attribute of man”*

**Charles Darwin**

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# RESUMO

Mudanças nos usos da terra e degradação ambiental devido a atividades humanas têm resultado em extremas alterações em ecossistemas tropicais, especialmente em riachos de cabeceira e suas bacias hidrográficas no Cerrado. Pressões humanas relacionadas à expansão agrícola e urbanização têm levado à redução drástica da cobertura vegetal nativa, comprometendo zonas ripárias, afetando e degradando ecossistemas aquáticos. Há uma necessidade urgente em quantificar e prever como as comunidades aquáticas respondem às mudanças nos usos do solo para orientar os esforços de conservação e manejo de recursos naturais. Esta tese teve como objetivo avaliar quais escalas espaciais mais influenciam as comunidades de macroinvertebrados bentônicos e como os usos da terra influenciam as relações tróficas e atributos biológicos de macroinvertebrados. O capítulo 1 avaliou como os usos da terra (representados por riachos em regiões de pastagem, plantação de cana de açúcar e vegetação nativa) influenciam o fluxo de energia e os nichos tróficos de macroinvertebrados. Em seguida foi avaliada qual escala espacial exerce maior influência na composição taxonômica e funcional de assembleias de macroinvertebrados (Capítulo 2). Por último, verificou-se a influência de um gradiente de distúrbios antrópicos sobre a diversidade funcional de assembleias de macroinvertebrados (Capítulo 3). Os resultados aqui apresentados demonstram que alterações nos usos do solo levam a comunidades de macroinvertebrados bentônicos em direção à comportamentos de alimentação mais generalistas e com maior sobreposição de nichos tróficos (Capítulo 1). Além disso, variáveis ambientais nas escalas local e regional explicaram significativamente variações na composição taxonômica e funcional de assembleias de Ephemeroptera, Plecoptera e Trichoptera, mas as métricas de uso do solo foram as que melhor explicaram as diferenças na composição funcional entre diferentes locais (Capítulo 2). E, por fim, foi observado que os sítios menos impactados (em condições de referência) têm assembleias de macroinvertebrados mais especializadas e mais diversas funcionalmente em comparação a locais perturbados (Capítulo 3). Os resultados encontrados corroboram que a biodiversidade deve ser avaliada em múltiplas escalas espaciais e que sejam considerados os elementos funcionais de comunidades biológicas, visando conservação e desenvolvimento de ferramentas preditivas. Este estudo contribui para uma melhor compreensão da estrutura e funcionamento de riachos na savana neotropical no contexto de subsidiar o desenvolvimento de instrumentos de avaliação ambiental. Tais abordagens contribuirão para o desenvolvimento de medidas mais adequadas de gestão e conservação que impeçam um avanço ainda maior da degradação de condições ecológicas de riachos tropicais.

**Palavras-chave**: escala espacial, uso da terra, atributos funcionais, fluxo de energia

# ABSTRACT

Changes in land cover and use and the associated environmental degradation due to human activities have resulted in extreme alterations of tropical ecosystems, especially in headwater streams and their watersheds in the neotropical savanna. Human pressures related to agricultural expansion and urbanization have led to drastic reductions in native vegetation cover, affecting riparian zones and degrading aquatic ecosystem functioning. There is an urgent need to quantify and predict how aquatic communities respond to different intensities of land use to guide conservation and natural resource management efforts. This thesis aims to evaluate how spatial scales influence the relationship between habitat and benthic macroinvertebrate communities and how land use intensity affects the trophic relationships and biological traits of macroinvertebrates. In Chapter 1, we evaluated how the intensity of land use (represented by a gradient moving from native vegetation toward pasture and sugar cane plantations) influences the energy flow and trophic niches of macroinvertebrates. In Chapter 2, we investigated the spatial scales (e.g., catchment, local) that most influence the taxonomic and functional composition of macroinvertebrate assemblages. Finally, in Chapter 3, we examined the impacts of human pressures on the functional diversity of macroinvertebrate assemblages. we showed that the intensity of land use affects benthic macroinvertebrate assemblages, yielding more generalist feeding behaviors with greater overlap of trophic niches (Chapter 1). In addition, environmental variables at the local and catchment scales significantly explained the variations in the taxonomic and functional composition of Ephemeroptera, Plecoptera and Trichoptera assemblages, but land use variables best explained the differences in functional composition among sites (Chapter 2). Finally, we showed that less impacted sites (under reference conditions) had more specialized and more functional diverse macroinvertebrate assemblages compared to disturbed sites (Chapter 3). These results corroborate the idea that biodiversity should be evaluated at multiple spatial scales and that the functional elements of biological communities should be considered when aiming for conservation and the development of predictive tools. This study contributes to a better understanding of the structure and functioning of streams in the neotropical savanna by subsidizing the development of environmental assessment tools. Such approaches will contribute to the development of more appropriate management and conservation measures that will allow for evaluation of the impacts on biota of further degradation of the ecological conditions in tropical streams.

**Key-words:** spatial scale, catchment, land use intensity, functional traits, energy flow

# RÉSUMÉ

Les changements d'intensité dans l'utilisation des sols et la dégradation de l'environnement en raison de activités humaines ont entraîné une forte altération des écosystèmes tropicaux, en particulier dans les cours d'eau de tête de bassin de la savane néotropicale. Les pressions humaines liées à l'expansion agricole et à l'urbanisation ont conduit à une réduction drastique de la couverture végétale indigène, affectant les zones riveraines et altérant le fonctionnement des écosystèmes aquatiques. Il est urgent de quantifier et de prévoir comment les communautés aquatiques répondent aux changements de l'utilisation des sols pour guider les efforts de conservation et de gestion des ressources naturelles. Dans ce contexte, cette thèse visait à évaluer à quelles échelles spatiales la relation entre habitat et communautés de macroinvertébrés benthiques s'exprimait le plus fortement et comment l'intensité d'utilisation des sols affectait les relations trophiques et la composition en traits biologiques des communautés de macroinvertébrés benthiques. Dans le chapitre 1, j'évalue comment l'intensité d'utilisation des sols (représentée par un gradient depuis la végétation autochtone, au pâturage, et à la plantation de canne à sucre et la végétation indigène) influe sur les flux d'énergie et les niches trophiques des macroinvertébrés benthiques. Ensuite, j'ai évalué à quelle échelle spatiale (bassin versant, localité) et pour quelles variables, le lien entre la composition taxonomique et fonctionnelle des assemblages de macroinvertébrés benthiques était le mieux exprimé (chapitre 2). Enfin, j'ai montré que les perturbations anthropiques avait unj impact sur la diversité fonctionnelle des assemblages de macroinvertébrés benthiques (chapitre 3). Les résultats présentés ici montrent que les changements d'intensité de l'utilisation des sols conduisent les assemblages de macroinvertébrés benthiques vers des comportements d'alimentation plus généralistes avec un chevauchement des niches trophiques (chapitre 1). De plus, les variables environnementales à l'échelle locale et du bassin versant expliquent de façon significative les variations de la composition taxonomique et fonctionnelle des assemblages d'Ephéméroptères, Plécoptères et Trichoptères, mais les variables décrivant l'intensité d'utilisation des sols expliquent le mieux les différences de composition fonctionnelle entre les différents sites (chapitre 2). Enfin, J'ai montré que les sites quasi-naturels (dans des conditions de référence) ont des assemblages de macroinvertébrés plus spécialisés comparés aux sites perturbés (chapitre 3). Les résultats corroborent le fait que la biodiversité doit être évaluée en tenant compte de variables agissant à de multiples échelles spatiales et que les éléments fonctionnels des communautés biologiques doivent être considérés, en vue de la conservation et du développement d'outils prédictifs. Cette étude contribue à une meilleure compréhension de la structure et du fonctionnement des cours d'eau dans la savane néotropicale dans le contexte du développement d'outils d'évaluation environnementale. Ces approches contribueront à l'élaboration de mesures de gestion et de conservation plus appropriées et permettront d'examiner les conséquences futures d'une poursuite de la dégradation des conditions écologiques dans les cours d'eau tropicaux.

**Mots clés**: échelle spatiale, basin versant, intesité d'utilisation des sols, traits fonctionnels, flux d'énergie

# RÉSUMÉ ETENDU

L'intensité d'utilisation des terres et le couvert végétal des bassins versants influencent grandement l'habitat physique et, par voie de conséquence, les assemblages aquatiques qui vivent dans les cours d'eau ainsi que les flux d'énergie au sein de ces écosystèmes. Depuis lontemps, les écosystèmes d'eau douce subissent de nombreuses pressions liées aux activités anthropiques, notamment l'agriculture et l'urbanisation, qui réduisent le couvert de la végétation autochtone, y compris la végétation des zones riveraines, ce qui affecte et induit la dégradation des écosystèmes aquatiques. De ce fait, les activités anthropiques conduisent à la simplification des habitats et à une réduction la diversité des communautés aquatiques, mettant en péril l'intégrité écologique et la soutenabilité des processus écologiques dans ces écosystèmes. Les cours d'eau tropicaux sont parmi les écosystèmes les plus menacés au monde, notamment ceux situés dans les pays en développement. Dans les cours d'eau néotropicaux, il est ainsi urgent de quantifier et de prévoir comment les communautés aquatiques répondent aux changements dans l'utilisation des terres pour guider les efforts de conservation et la gestion des ressources aquatiques.

Depuis plus de 100 ans, les macroinvertébrés aquatiques sont utilisés comme bio-indicateurs de la qualité de l'eau et leur utilisation dans l'évaluation de l'intégrité écologique des cours d'eau tropicaux s'est accrue ces dernières années. Les approches traditionnelles pour évaluer les effets des perturbations anthropiques portent généralement sur la structure taxonomique des communautés (ex. richesse, abondance, diversité) et des indices multimétriques ont été proposés pour évaluer l'état de santé des cours d'eau. Cependant, ces indices basés sur la composition et l'abondance des organismes sont limités à la région dans laquelle ils ont été développés, car il existe une variation considérable de la distribution des espèces due à leur répartition biogéographique. L'utilisation d'approches prenant en compte les différences évolutives ou fonctionnelles entre les espèces peut améliorer les indicateurs standard pour évaluer l'état écologique des écosystèmes aquatiques. Depuis une vingtaine d'années, les traits d'espèces sont suggérés comme une approche alternative et

complémentaire des approches taxonomiques traditionnelles pour élucider les changements dans les communautés aquatiques liés à des perturbations naturelles ou anthropiques. Cette approche fondée initialement sur le concept théorique d'habitat templet a fourni de nombreuses applications pratiques dans l'évaluation écologique de la santé des cours d'eau.

Les évaluations écologiques utilisant les traits d'espèces offrent plusieurs avantages par rapport aux évaluations taxonomiques, telles que: (i) une plus grande stabilité de réponse de la composition en traits des communautés à large échelle spatiale par rapport à la composition taxonomique, ce qui permet d'étendre l'approche à différentes régions biogéographiques; (ii) un très large éventail de réponses aux facteurs de stress multiples; et (iii) la possibilité d'une compréhension plus mécanistes des phénomènes en jeu dans la relation espèces-environnement.

La plupart des études portant sur l'importance relative des échelles locales et régionales sur la composition en traits et taxonomique des assemblages dans les écosystèmes d'eau douce est limitées aux régions tempérées et boréales. L'identification du mode d'action des pressions anthropiques sur la composition en traits des communautés est susceptible d'améliorer notre capacité prédictive dans les modèles liant habitat et communuatés biologiques, d'améliorer notre connaissance des processus en jeu dans les écosystèmes d'eau douce et d'aider au développement d'outils plus spécifiques que les évaluations traditionnelles pour les actions de gestion et les initiatives de conservation.

Dans cette thèse, mon objectif était d’étudier et de comprendre comment le couvert végétal et l'intensité d'utilisation des terres affectent la composition taxonomique et en traits des assemblages aquatiques ainsi que les relations trophiques dans les cours d'eau de tête de bassin en savane néotropicale. J'ai acquis des données sur les isotopes stables, des données sur les habitats et les paysages issues d'analyse d'imagerie satellitaire et des données sur la composition en taxons et en traits de assemblages d'insectes aquatiques pour étudier trois ensembles d'objectifs interdépendants correspondant à trois chapitres de la thèse.

Dans le premier chapitre (Castro et al., 2016, PloS One 11, e0150527), j'ai utilisé la technique des isotopes stables pour évaluer comment l'intensité d'utilisation des terres (représentée par un gradient depuis la végétation autochtone vers les pâturages et les plantations de canne à sucre) influence les flux énergétiques et les niches trophiques dans les assemblages aquatiques des cours d'eau néotropicaux. Les macroinvertébrés ont été échantillonnés et classés en groupes fonctionnels d'alimentation et les ressources trophiques disponibles ont été échantillonnées et leur composition isotopique en $^{13}C$ et $^{15}N$ a été identifiée le long de cours d'eau situés dans le biome du Cerrado (savane néotropicale). Les résultats montrent que les cours d'eau sous influence de pâturages ou de plantations de canne à sucre ont des niches trophiques plus larges et plus chevauchantes, ce qui correspond à des habitudes alimentaires plus généralistes de la part des invertébrés présents. En revanche, les groupes trophiques des cours d'eau traversant la végétation autochtone ont des niches trophiques plus étroites avec peu de chevauchements suggérant une plus grande spécialisation. Les sites sous influence de pâturages ont une plus grande gamme de ressources exploitées, ce qui indique une plus grande diversité trophique que les sites à couvert végétal naturel et la plantation de canne à sucre. Nous pouvons conclure que l'augmentation de l'intensité d'utilisation des terres modifient les réseaux trophiques et déplacent les assemblages de macroinvertébrés vers des comportements alimentaire plus généralistes et un chevauchement plus important des niches trophiques.

Dans le deuxième chapitre, j'ai évalué l'importance de la localisation géographique, du couvert végétal et de l'utilisation des bassins versants (décrit par 20 variables) et l'habitat physico-chimique local (décrit par 55 variables: hydromorphologie, substrat, écoulement, forêt ripariale et qualité de l'eau) dans les modifications de la composition taxonomique et fonctionnelle des assemblages d'Ephéméroptères, de Plécoptères et Trichoptères (EPT). Les traits des taxons EPT ont été quantifiés en utilisant 28 catégories de 7 traits biologiques, ce qui représente les meilleures connaissances actuellement disponibles pour les taxons EPT dans les cours d'eau néotropicaux de savane. Nous avons ensuite analysé les relations entre les variables définie à l'échelle des bassins versants et celles définies au niveau de l'habitat local (site) et la composition taxonomique et en traits des assemblages d'insectes recueillis dans 160 sites. Les variables définies à l'échelle des bassins versants et de l'échelle locale du site contribuent à la variation significative de la composition taxonomique  et en traits des taxons EPT. Le substrat et l'hydromorphologie locale ainsi que l'intensité d'utilisation des terres dans les bassins versants influencent le plus fortement la composition taxonomique alors que la composition des assemblages en traits est essentiellement liée à l'intensité d'utilisation des terres. La position géographique représente une plus faible part explicative de la variation des assemblages d'EPT, du fait d'une combinaison de l'histoire évolutive des genres d'EPT et de leurs capacités de dispersion variable.

Dans le troisième chapitre, j'ai étudié les changements dans la composition des assemblages d'EPT le long d'un gradient de perturbation anthropique séparant des cours d'eau de tête de bassin de référence, de cours d'eau moyennement ou fortement perturbés par les activités anthropiques. Alors que la richesse des genres d'EPT ne diffère pas entre niveaux de perturbation, la richesse et la diversité fonctionnelle montrent une diminution significative avec l'augmentation du niveau de perturbation. Nos résultats sur la réponse aux perturbation de la taille, la forme et la flexibilité du corps des organismes, de leur nombre de cycles de reproduction par an, de leur locomotion, et la relation au substrat avec les hypothèses faites a priori du substrat sur la réponse des traits aux changements d'intensité dans l'utilisation des terres des bassins versants, l'habitat physique et la qualité de l'eau. En combinant les analyses RLQ et dite "quatrième coin" , nous montrons que 12 des 28 catégories de traits disponibles sont significativement associées à des changements d'intensité de l'utilisation des terres des bassins versants, de l'habitat physique et de la qualité de l'eau, le long du gradient de perturbation. La proportion d'individus ayant une grande taille corporelle, peu flexible, <1 cycle de reproduction par an, constructeur d'étui nymphaux (Trichoptères) et se déplaçant comme "climber" caractérisent les assemblages d'EPT des cours d'eau les moins perturbés. Enfin, les assemblages d'EPT des cours d'eau les moins perturbés montrent une spécialisation des traits beaucoup plus élevée par rapport aux cours d'eau perturbés contenant plus de taxons généralistes..

Cette thèse est une première évaluation quantitative et multi-échelle des conséquences des perturbations anthropiques sur les compositions taxonomiques et en traits des taxons EPT et sur les relations trophiques dans les cours d'eau de tête de savane néotropicale. En premier lieu je contribue à un accroissement des connaissance à travers l'élaboration d'une base de données de traits EPT spécifique, élaborée après une étude robuste et exhaustive de la littérature néotropicale exclusivement. J'ai sélectionné six traits (parmi ~ 15 possibles) possédant suffisamment d'informations fiables. En second lieu, j'ai pu identifier quelle échelle spatiale et quelles variables de perturbation anthropogéniques influencent le plus la composition taxonomique et les traits des assemblages d'EPT dans les cours d'eau de tête de bassin. Enfin, j'ai observé que les changements dans l'utilisation des terres conduisent à l'homogénéisation des communautés en termes de composition fonctionnelle. Cette étude contribue à une meilleure compréhension de la structure et du fonctionnement des cours d'eau néotropicaux de savane dans le contexte de la conception future d'outils d'évaluation pour la définition des aires de conservation prioritaires et l'élaboration d'indices d'intégrité biologique et fonctionnelle. De telles approches permettront d'élaborer des mesures de gestion et de conservation appropriées pour prévenir la dégradation des conditions écologiques.

# GENERAL CONTEXT


Word cloud showing the main words and concepts used in this PhD. thesis.

# SUMMARY

# INTRODUCTION

The growth of the human population, rising consumption and the overexploitation of natural resources have caused the widespread alteration and disruption of natural systems, especially in freshwater ecosystems (Abell et al. 2008). These ecosystems have lost a great proportion of their species and habitat, and tropical biomes are at the forefront of these environmental problems (Laurance and Peres 2006). The loss of biodiversity in rivers, including the diversity of benthic organisms, is occurring at an alarming and increasing rate (Allan and Castillo 2007). This is because rivers have experienced many influences from human activities, such as sewage release, the destruction and degradation of habitats, the introduction of exotic species, and flow regulation (Dudgeon et al. 2006). These changes have generally led to the simplification of habitats and have reduced the diversity of aquatic communities, imperiling the ecological integrity and sustainability of ecological processes in these ecosystems (Cardinale et al. 2012). Tropical streams are among the most threatened ecosystems in the world (Dudgeon et al. 2006), but the pace of stream deterioration exceeds the pace of scientific research aimed at understanding ecosystem responses (Ramírez et al. 2008). In Brazil, all of these problems have affected the quality of water bodies, especially near urban centers and industrial development areas (Tejerina-Garro et al. 2005, Hepp et al. 2010).

The intensity of land use and the type of land cover in the catchments of aquatic systems greatly influence the physical habitat and, consequently, the aquatic communities and energy flow (Allan 2004, di Lascio et al. 2013). Agriculture and urbanization tend to reduce the coverage of native vegetation, including vegetation in the riparian zone, affecting and degrading aquatic ecosystems (Dudgeon et al. 2006). The resulting changes in physical habitat include increases in the sedimentation rate, changes in the hydrological regime, and increased water temperature and nutrient concentrations, which in combination, significantly impact aquatic biodiversity (Bryce et al. 2010, Hughes et al. 2010, Woodward et al. 2012) and ecosystem functioning (De Laender et al. 2016). In neotropical streams in particular, there is an urgent need to quantify and understand how aquatic communities respond to changes in land use to guide conservation efforts and the management of ecological resources.

Aquatic macroinvertebrates are widely used as bio-indicators of water quality (Rosenberg and Resh 1993, Bonada et al. 2006), and their usage in assessing the biotic integrity of tropical streams has increased in recent years (Ferreira et al. 2011, Oliveira et al. 2011, Ligeiro et al. 2013, Dedieu et al. 2016). Among macroinvertebrates, Ephemeroptera, Plecoptera and Trichoptera (EPT) comprise highly diverse aquatic assemblages in headwater streams (Bispo et al. 2006) and have important roles in nutrient cycling and energy transfer (Ferreira et al. 2014). In addition, EPT richness, for example, is a common metric for assessing the biological conditions of stream ecosystems (Stoddard et al. 2008). Traditional approaches to assessing anthropogenic disturbance have usually focused on the taxonomic structure of biological communities (e.g., species richness, abundance/density, and diversity, although some have used traits, such as feeding groups), and multimetric indices have recently been proposed to assess environmental conditions (Moya et al. 2011, Couceiro et al. 2012, Macedo et al. 2016). However, the use of indices based on the composition and abundance of organisms is restricted to the region in which these indices were developed because there is considerable ecological variation due to the biogeographic distribution of species, which changes over large spatial scales (Heino 2001, Bonada et al. 2007). Thus, the observed patterns may result from natural stochastic variations, which are independent of the changes associated with human disturbance (Dolédec et al. 2011). In that respect, the use of approaches that account for the evolutionary, biological, ecological, or functional differences between species allows for the improvement of the standard indices developed to assess the environmental conditions of rivers (Petchey and Gaston 2002, McGill et al. 2006, Villéger et al. 2008).

To augment the conservation and management of tropical freshwater ecosystems, it is essential to develop biological tools that incorporate ecological information such as biological traits (Usseglio-Polatera et al. 2000b, Delong and Thorp 2006, Tomanova et al. 2008). Furthermore, it is fundamental to understand at what spatial scale and under which types of human impact the differences in aquatic assemblages occur.

## *Spatial scales as environmental filters*

Environmental patterns within a watershed directly affect the structure of biological communities in a hierarchically nested manner (Vannote et al. 1980, Frissell et al. 1986, Leps et al. 2015, Wojciechowski et al. 2017). At a large spatial scale, climate, geology and topography influence the geomorphic processes that govern smaller-scale energy inputs and local habitats (for example, determining the shape of river channels and network connectivity) for aquatic communities (Frissell et al. 1986, Allan 2004, Goldstein et al. 2007). Local physical and chemical habitats are thus determined by larger-scale processes (Leal et al. 2016), which makes it even more difficult to disentangle the role of the different environmental drivers acting on aquatic communities (Frissell et al. 1986, Allan 2004). Therefore, considering spatial scale in freshwater ecology studies is essential for a comprehensive understanding of the drivers that determine the structural and functional diversity of stream communities (Heino et al. 2003, Sandin and Johnson 2004, Hoeinghaus et al. 2007, Macedo et al. 2014, Liu et al. 2016).

The multiple spatial scales (e.g., region, river catchment, channel unit, and microhabitat) that structure biological communities are related to the idea of environmental filters. Each species possesses a specific set of traits that allows them to withstand habitat filters acting over multiple spatial scales, thereby determining their distribution pattern (Townsend and Hildrew 1994, Poff 1997). Considering the selective action of habitat filters at multiple scales can increase our understanding and predictive ability in ecology. Accordingly, identifying species traits that are sensitive to habitat characteristics at different spatial levels will likely enhance our ability to predict how species distributions are regulated across the landscape.

## *Human disturbances*

Human disturbances are widely recognized as major threats to terrestrial and aquatic biodiversity worldwide (Vörösmarty et al. 2010, Carpenter et al. 2011, Dirzo et al. 2014). Freshwater ecosystems are especially vulnerable to anthropogenic disturbances because human populations generally settle close to rivers or in their surrounding catchment areas. Human activities can alter the balance of the natural forcing factors in aquatic ecosystems, for example, by changing the relative abundance of different substratum types or altering the mean annual temperature regime. Such impacts can cause changes that are beyond the normal conditions expected for a given lotic ecosystem and affect ecosystem structure and function (Malmqvist and Rundle 2002). Moreover, multiple stressor effects associated with human activities also cause declines in freshwater biodiversity (Dudgeon et al. 2006, Vörösmarty et al. 2010).

The major human-induced drivers of change in freshwater ecosystems include hydrological regime modification, land use intensity, chemical inputs, exotic species, and harvesting. All drivers play a role, but some of them have substantial effects on freshwater systems (Carpenter et al. 2011). In particular, the intensity of land use, the amount of conversion of natural lands to human use and the alteration of management practices in human-dominated lands are major drivers of ecosystem change (Foley et al. 2005). Land use intensity affects geomorphological processes, causing channel hydromorphological changes, bottom siltation, substrate homogenization, decreases in flow variability (Allan, 2004), reduced litter input from riparian vegetation (Boyero et al. 2016), and water quality alteration (Woodward et al. 2012, Taylor et al. 2014). Such human-induced ecosystem changes are observed at multiple spatial scales (global, regional, local), constituting a complex and interconnected system (Rockström et al. 2009).

## *Energy flow and trophic relationships*

In freshwater ecosystems, aquatic invertebrates are the main link between primary producers (e.g., periphyton and aquatic macrophytes) and higher trophic levels (e.g., vertebrates). By breaking down organic matter, these invertebrates contribute to litter decomposition and nutrient availability for other organisms (Wallace and Webster 1996, Covich et al. 1999, Jardine et al. 2005). Aquatic macroinvertebrates have been classified according to their feeding habits into functional feeding groups (FFG) based on morphological and behavioral characteristics (Cummins 1973, Merritt et al. 2008). Each of these groups relies on specific food resources, which are in turn influenced by different habitat characteristics. These groups include (i) scrapers that feed on organic matter bound to organic and inorganic substrates (e.g., periphyton, algae and their associated microbiota); (ii) shredders that feed directly on coarse particulate organic matter (CPOM); (iii) gathering-collectors that feed mainly on deposited fine particulate organic matter (FPOM); (iv) filtering-collectors that filter fine suspended organic matter; and (v) predators that feed on whole animals or their parts (Wallace and Webster 1996, Merritt et al. 2008).

Identifying and quantifying the trophic relationships between aquatic macroinvertebrates are essential to a better understanding of the functional relationships between organisms and the environment (Cardinale 2011, Thompson et al. 2012, Rooney and McCann 2012). Therefore, analyzing the trophic relationships among macroinvertebrates and the energy flow in aquatic ecosystems is required to understand community structures and dynamics and ecosystem functioning (Polis et al. 1997, Perkins et al. 2014).

To improve environmental assessments and inform the management of aquatic ecosystems, it is essential to understand how the intensity of land use influences the energy flow and trophic relationships in aquatic environments (Delong and Thorp 2006). Changes in vegetation cover affect the nutrient input, food resource quality, and energy flow, which can lead to the simplification of food webs and a loss of biodiversity (Lorion and Kennedy 2009, Ferreira et al. 2012). The replacement of native vegetation by monocultures (e.g., pasture, sugarcane) disturbs ecosystem function and the sources that supply aquatic environments (Leberfinger et al. 2011) by modifying the structure and dynamics of aquatic communities that are dependent on allochthonous material provided by the surrounding vegetation and canopy cover (Ormerod et al. 1993, Dudgeon 1994, Ferreira et al. 2012).

Assessments of the energy flow, trophic structure, and trophic relationships between organisms can be obtained using stable isotopes (Post 2002, Layman et al. 2007, Boecklen et al. 2011, Perkins et al. 2014). The information yielded by isotopic signals allows us to (i) know the origin of organic matter (Post 2002), (ii) examine resource partitioning (Young et al. 2010), (iii) map the ecosystem fluxes of carbon and nitrogen (Peterson & Fry, 1987), (iv) characterize niche properties (Newsome et al. 2007) and (v) compare the ecological processes of riparian areas in different regions (Carvalho et al. 2017). The use of the stable isotope ratios of carbon (δ13C) and nitrogen (δ15N) as indicators of anthropogenic disturbances was first proposed by

Peterson and Fry (1987). The use of this method in trophic ecology has intensified in recent years (Medeiros and Arthington 2011, Blanchette et al. 2014, Rigolet et al. 2015, Bentivoglio et al. 2016, Greaver et al. 2016, Jackson et al. 2016), mainly for the purpose of describing the relationships between sources of organic matter, food chains and sources of pollution (Davis et al. 2012, Turner and Edwards 2012, Morrissey et al. 2013), contributing to the understanding of ecological processes in streams (di Lascio et al. 2013).

In δ-space (a bi-plot where each axis is defined by the isotopic values, i.e., δ13C and δ15N), the isotopic values define an area called the isotopic niche (Bearhop et al. 2004). As the δ13C and δ15N values of a species are the result of all trophic pathways, the position in δ-space is one representation of the species' trophic niche (Layman et al. 2007). Trophic niche is a part of the ecological niche that uses a subset of dimensions related to trophic resources. The isotopic niche space is defined as the range of stable isotope values and provides insight into resource partitioning. In a coarse analogy with Hutchinson's (1957) n-dimensional niches, the isotopic niche is a subset of a multivariate space (Newsome et al. 2007). Although the isotopic niche is likely to be tightly correlated with the trophic niche, it is important to highlight that these are two different concepts that should not be mixed together. Nevertheless, the information contained within stable isotope ratios can be considered to be a descriptor of the key axes in Hutchinson's hypervolume, thus providing ecologically relevant information about the biological assemblages they represent (Bearhop et al. 2004, Jackson et al. 2011). An overlap in the isotopic niches of two consumers indicates the use of the same primary resources, whereas isotopic niche segregation demonstrates that the consumers use different resources. Human activities can alter the trophic niche of macroinvertebrates and their degree of overlap (Bearhop et al. 2004, Layman et al. 2007), potentially leading to communities with more generalist species.

## *Community specialization*

Ecological specialization refers to the area in ecological niche space used by a species due to its specific traits (Futuyma and Moreno 1988). In freshwater systems, the replacement of habitat specialists by generalist species has been suggested to occur as a response of assemblages to human activities, such as habitat degradation and land use intensity (Olden et al. 2004, Petsch 2016). Functional homogenization at the community level can alter ecosystem functioning and productivity and can result in the deterioration of ecosystem services (Clavel et al. 2011). At the community level, specialization can be estimated as the mean specialization of the species present in that community and can be used to develop indicators of conservation interest (Devictor et al. 2010).

The ecologically significant functional changes that can occur in homogenized communities are largely independent of taxonomic identities. Thus, a more subtle ecological examination of homogenization is required (Olden et al. 2004). In freshwater ecosystems, the replacement of habitat specialists by habitat generalists has been shown to occur as a response of assemblages to habitat degradation and land cover alteration (Petsch, 2016, Siqueira et al., 2015). This replacement may lead to a functional homogenization (i.e., increasing species feature similarities) (Mondy and Usseglio-Polatera 2014), which may, in turn, increase species' vulnerability to environmental changes and decrease resilience and/or resistance to disturbances (Olden et al., 2004). Therefore, understanding the consequences of community homogenization due to human activities and identifying the main drivers causing these changes are critical for basic science and conservation.

## *Biological traits and ecological requirements*

A trait is defined as any morphological, physiological or phenological feature measurable at the individual level (Violle et al. 2007). These features are measurable properties of an organism and are divided into biological (e.g., life cycle, maximum body size, mobility, reproduction) and ecological (related to habitat preference, such as temperature and organic pollution tolerances) features, reflecting the adaptations of organisms to environmental conditions (Menezes et al. 2010). Functional traits can be defined as traits that influence organismal fitness (via their effects on growth, reproduction and survival) and the functioning of ecosystems (Violle et al. 2007) and can be used to assess community functional diversity (Petchey and Gaston 2006). Species traits have been suggested as an alternative or complementary approach to the more traditional taxonomic approaches used to elucidate community changes in freshwater ecosystems and have provided numerous practical applications in river assessment (Statzner and Bêche 2010, Culp et al. 2011, Mondy et al. 2012). Moreover, functional traits have been proven to serve as a promising proxy for community or ecosystem function in response to various types of disturbance (Tilman et al. 1997, Verberk et al. 2013, Enquist et al. 2015, Gagic et al. 2015), such as changes in land use (Vandewalle et al. 2010, Dolédec et al. 2011). However, our understanding of the way in which the functional diversity of macroinvertebrate communities influences patterns and processes in freshwater ecosystems needs to be broadened (Schmera et al. 2017).

From an ecosystem management perspective, trait-based assessments are expected to offer several advantages and practical applications over taxonomy-based assessments (Culp et al. 2011). The linkage of trait responses to disturbance offer the following advantages: (i) The trait composition of assemblages is more spatially stable than the taxonomic composition, allowing for comparisons between different biogeographic regions, overcoming variations in site-specific taxonomic composition (Statzner et al. 2001, 2004); (ii) traits cover a broad range of responses to multiple stressors (Dolédec et al. 1999; Mondy et al. 2016); and (iii) traits allow a more mechanistic understanding that can give access to the causes of change (Culp et al. 2011, Verberk et al. 2013). Many studies, especially in Europe, (e.g., Usseglio-Polatera and Beisel 2002, Statzner et al. 2005, Dolédec et al. 2006, 2011, Archaimbault et al. 2010) have demonstrated that the multiple trait-based approach can better detect the impact of human activities on aquatic ecosystems compared to traditional methods (e.g., diversity indices or chemical analysis).

The processes driving the relationships between biological assemblages and their environment have been described using ecological theories. The ‘Habitat Templet’ (Southwood 1977) and its riverine adaptation, the ‘River Habitat Templet’ (RHT; Townsend and Hildrew (1994)), have emphasized that specific combinations of traits determine the ability of individuals to coexist in a local community under specific environmental conditions. Derived from these theories, the habitat-filtering hypothesis (Poff 1997) postulates that the least suitable sets of biological traits are eliminated in a given environment and that only taxa possessing traits that pass through the habitat filter will be present in the community. There is thus a higher correspondence between environmental conditions and trait composition than between environmental conditions and species composition due to a filtering of traits. In this context, human disturbances represent additional environmental filters that can change the expected trait composition of assemblages in natural conditions (Floury et al. 2017).

Using a functional trait approach thus allows for assessments of the extent of niche occupation, the regularity of species traits within the assemblage, the level of functional specialization and redundancy, and the individual trait contribution to the assemblage structure (Villéger et al. 2008, Mouillot et al. 2013). Identifying how human pressures modify the trait composition of assemblages can improve our ability to predict patterns and processes in freshwater ecosystems and aid in the development of tools that complement traditional assessments for management actions and conservation initiatives (Jonsson et al. 2016; Pallottini et al. 2016).

# GENERAL METHODOLOGY

This chapter is dedicated to the overall methodology used in this thesis. First, I give a short description of neotropical savannas and the procedures used to select the sampling sites. Then, I describe the laboratory activities, macroinvertebrate sampling and identification, and isotope analysis procedures. Finally, I explain how the environmental variables were quantified and how I built the trait database used in the analysis. The statistical analyses are further presented in the respective chapters.

## *Study area*

### Neotropical savanna

The neotropical region is one of the eight biogeographic realms constituting the Earth's regions and covers South and Central America and the Caribbean (Udvardy 1975). The Neotropics contain significant areas of tropical rainforests (e.g., the Amazon and Atlantic Forests), seasonally dry forests (e.g., Caatinga) and savannas (e.g., Cerrado) (Pennington et al. 2006).

The Cerrado biome (neotropical savanna) is the second largest in South America (after the Amazon). This biodiversity hotspot is one of the most threatened biomes in the world (Myers et al. 2000). The Brazilian Cerrado has been the object of increasing anthropic pressure for many years, but the effects of land cover and land use changes in this ecosystem have been largely overlooked, with very few research and conservation efforts (Beuchle et al. 2015).

Since the 1970s, this region has suffered heavy losses of natural vegetation due to agricultural expansion, with natural vegetation being replaced with pasture and row crop agriculture (Hunke et al. 2015). According to Pennington et al. (2006), the areas cleared in the Brazilian Cerrado greatly exceed those cleared in the Amazon rainforest (Figure 1). Such agricultural activities have altered 40% of the native terrestrial plant cover (Foley et al. 2005) and have reduced or removed the native riparian vegetation, thereby degrading the ecological integrity of aquatic ecosystems (Macedo et al. 2014).

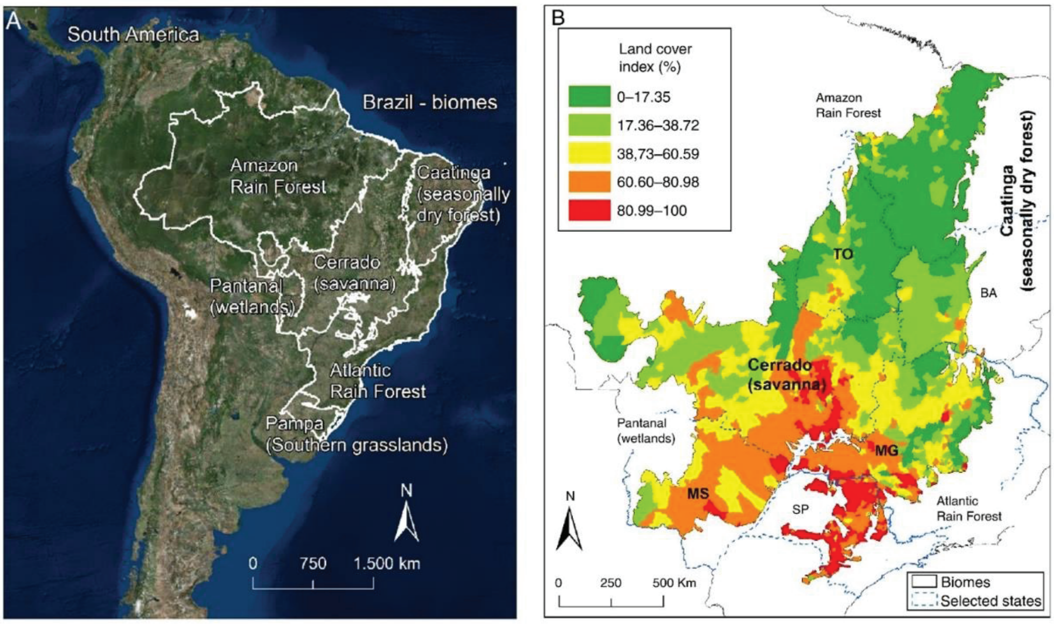


**Figure 1**: Original distribution of the Cerrado biome (Neotropical savanna) in South America (A) and the remnant area of Cerrado (year 2008) (B). In the land cover index, the lower the percentage value, the less human land conversion. Image adapted from Fernandes et al. (2016).

## Hydrological units

Sampling campaigns were carried out in “wadeable streams” (rivers that can be crossed by feet for an average adult) of orders and dimensions of similar width and depth (Peck et al. 2006). Four sub-basins were selected in the Cerrado biome of the Minas Gerais state, upstream reservoirs of Nova Ponte (Araguari River Basin), Volta Grande (Grande River Basin), Três Marias (São Francisco River Basin) and São Simão (Paranaíba River Basin) (Figure 2). The four hydrological units were defined as the contributing drainage areas within 35 km upstream of each of four major hydropower reservoirs.

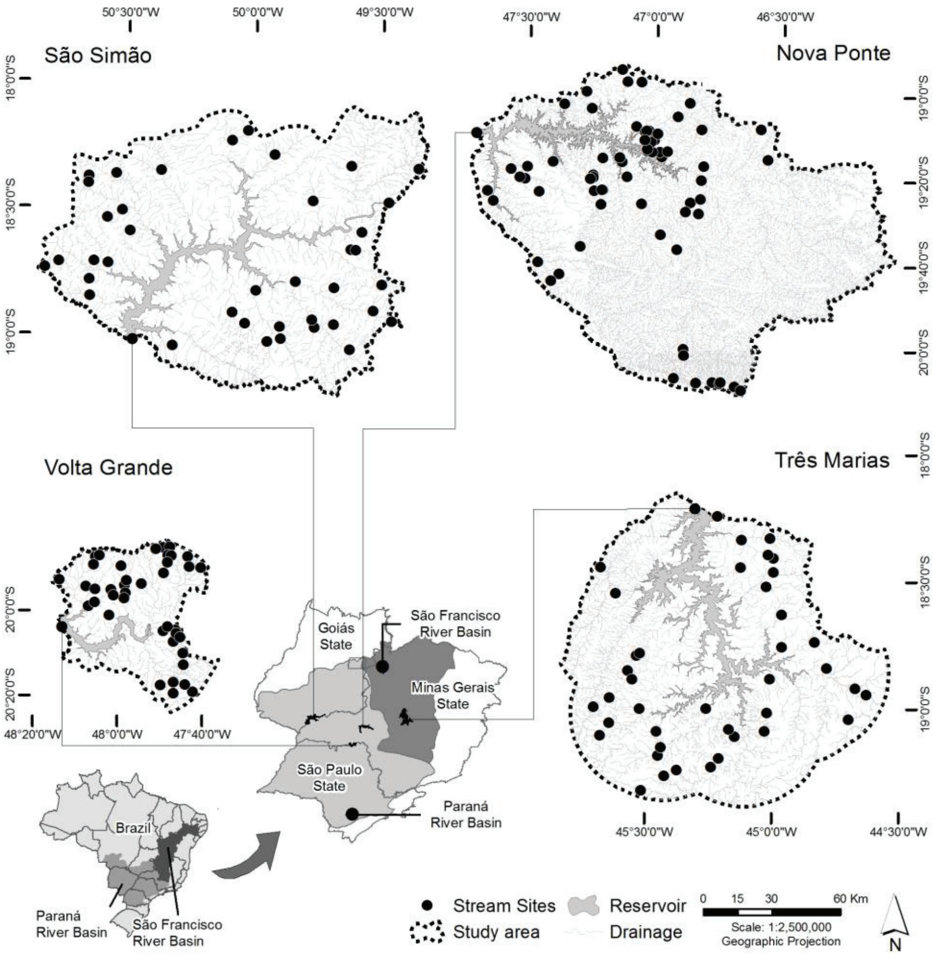


**Figure 2**: Locations of hydrological units and streams sites sampled in the Brazilian Neotropical savanna.

## *Sampling design*

The site selection employed a spatially balanced probabilistic survey (Stevens and Olsen 2004) used by the U.S. Environmental Protection Agency (US-EPA) in its regional and national biomonitoring programs (Olsen and Peck 2008). In each of these hydrological units, 40 wadeable stream sites ranging from 1st to 3rd order were selected, totaling 160 randomly selected sites. In this approach, a master sample frame was first established using a digital hydrographical map (1:100,000 scale), and the sample sites were selected using a hierarchical, spatially weighted criterion (Stevens and Olsen 2004). We also included a set of 26 handpicked reference sites, considered to be the least-disturbed, located in Serra da Canastra National Park and the Serra do Salitre region in the Paraná River Basin (Nova Ponte hydrologic unit).

We sampled in September from 2010 to 2013, one year for each of the aforementioned hydrological units, ensuring that samples were all taken in the low flow season.

**Figure 3**: Some examples of headwater streams in the Cerrado biome showing different types of land use. Left side: least disturbed sites. Right side: disturbed sites. Image source: Laboratório de Ecologia de Bentos.

## Stable isotope sampling

Within the São Simão hydrological unit, we selected 9 streams out of the 40 that were randomly selected for the collection of additional qualitative samples of macroinvertebrates and organic matter for stable isotopic analyses. We selected 3 streams in least-disturbed settings, 3 in pasture areas, and 3 in sugarcane areas. In those 9 streams, we considered the following: macroinvertebrates classified in different trophic functional groups (predators, scrapers, shredders, and filtering and gathering collectors), coarse particulate organic matter (CPOM), fine particulate organic matter (FPOM), periphyton, macrophytes, leaves from the riparian vegetation, and suspended particulate organic matter.

## Invertebrate sampling and laboratory activities

We sampled aquatic insects at all 186 sites with a D-frame kick-net (30 cm aperture, 500 m mesh, and 0.09 m² area) for a total of 0.99 m² per site. Samples were collected along 11 equidistant transects on a systematic zigzag path throughout each site (minimum length of 150 m), as described in Hughes and Peck (2008), and samples were fixed in 4% formalin. We grouped all subsamples into a single pooled sample for each site. In the laboratory, the samples were sorted in different trays, and the organisms were identified at the family level under a stereoscopic microscope (Zeiss 32x) using taxonomic keys (Róldan-Pérez 1988, Merritt et al. 2008, Mugnai et al. 2010). The EPT individuals were identified at the genus level (Pes et al. 2005, Dominguez et al. 2006, Salles 2006, Mugnai et al. 2010) (Appendix 3).

## Catchment land use and cover

We classified land use and cover within the upstream catchment of each site by interpreting a combination of high-resolution satellite images (0.6–5.0 m spatial resolution, Google Earth data: Google 2014) and Landsat multispectral satellite images (R4G3B2 false color band combination). The high-resolution images provided information about the shape and texture of the elements, and the multispectral images allowed for the distinction of vegetation leaf structure. We identified four natural savanna cover types (woodland savanna, grassy-woody savanna, parkland savanna, and wetland palm swamp) (IBGE 2012) and four human-influenced land use (pasture, agriculture, eucalyptus forest, and urban areas) in the 186 sites (Appendix 2).

## Physical habitat structure and water quality

At each site, the physical habitat was characterized using the standardized U.S. EPA field methods (Peck et al. 2006, Hughes and Peck 2008) adapted to neotropical savanna headwater streams by Callisto et al. (2014). At each site, we characterized the channel morphology, riparian structure, flow type, substrate type, and in-stream habitat cover (Kaufmann et al. 1999, 2009). The catchment and local scale were initially described by ~250 variables. We further eliminated those variables that had more than 90% zero values, low variability and high correlation with each other ($r > |0.8|$). These steps yielded a final set of 75 variables (Macedo et al. 2014). To assess the physical and chemical parameters of the water, we measured the temperature (°C), electrical conductivity (µS $cm^{-1}$), pH, turbidity (NTU), and total dissolved solids (mg $L^{-1}$) in situ with a multi-probe (YSI, 650 MDS, model 6920). The total nitrogen (mg $L^{-1}$) and dissolved oxygen concentrations (mg $L^{-1}$) were determined from preserved water samples in the lab following Standard Methods (APHA 2005) (Appendix 2).

## Isotopes analysis

All samples collected in the field were packed in a cooler with ice and subsequently frozen. At the laboratory, the samples of leaves, CPOM, FPOM, and macrophytes were dried at 60°C, ground, and stored in Eppendorf tubes. Periphyton and organic matter in suspension were filtered through glass fiber filters that had been calcined. Filters were dried, ground, and stored in Eppendorf tubes. Macroinvertebrate samples were washed and sorted. The organisms were then identified and classified according to their trophic functional groups and dried at 60°C for 48 h. The organisms were ground with the aid of a mortar and pestle and then stored in Eppendorf tubes.

Samples were sent to the Laboratório de Ecologia Isotópica in Centro de Energia Nuclear na Agricultura (CENA) of Escola Superior de Agricultura "Luiz de Queiroz" (ESALQ-USP), in Piracicaba, São Paulo. Isotopic analyses were performed (using a Thermo Finnigan Delta Plus mass spectrometer) by combusting samples under a continuous flow of helium in an elemental analyzer (Carlo Erba, CHN 1110). Ratios were expressed using the standard delta (δ) per mil notation:

$$\delta X = [(R_{sample}/R_{standard}) - 1] \times 10^3$$

where X is $^{13}C$ or $^{15}N$ and R are the $^{13}C$:$^{12}C$ or $^{15}N$:$^{14}N$ ratios of the samples and the standard.

## *Biological trait database*

### Neotropical literature

In the Neotropics, knowledge about the ecology and biological traits of tropical aquatic invertebrates is very scarce, despite some recent studies (Tomanova and Usseglio-Polatera 2007, Tomanova et al. 2008, Reynaga and Santos 2013, Dedieu et al. 2015, Milesi et al. 2016). In Brazil, few studies have considered multiple trait-based approaches (e.g., Colzani et al. 2013, Saito et al. 2015b, 2015a). However, these studies have generally used trait databases designed for temperate regions (e.g., Poff et al. 2006, Vieira et al. 2006), even though the characteristics of taxa may greatly differ between regions.

I carried out an intensive survey of the literature, and the biological trait structure of the invertebrate assemblage was described using 28 categories of 7 biological traits (Table 1). I used trait information that was available exclusively for neotropical macroinvertebrates (Baptista et al. 2006, Tomanova and Usseglio-Polatera 2007, Reynaga and Santos 2012, Dedieu et al. 2015). Biological traits and their respective trait categories described the EPT genus profile in terms of its morphology, life-cycle features, resilience, resistance to disturbance and feeding behavior (Appendix 1). This database represents the best available trait knowledge on Brazilian EPT.

**Table 1.** Traits and their categories used for 73 EPT genera collected in Neotropical savanna streams.

| Trait | Category |
|---|---|
| Body size (mm) | <1.5<br>1.5 - 2.5<br>2.5 - 3.5<br>3.5 - 5.0<br>5.0 - 10.0<br>>10 |
| Potential number of reproductive cycles per year | < or = 1<br>> 1 |
| Feeding habits | Collector-Gatherer<br>Shredder<br>Scraper<br>Collector-Filterer<br>Predator |
| Locomotion | Burrower<br>Climber<br>Sprawler<br>Clinger<br>Swimmer |
| Body flexibility (°) | <10<br>>10-45<br>>45 |
| Body form | Streamlined<br>Flattened<br>Cylindrical<br>Spherical |
| Relation to substrate | Free living<br>Silk net builders<br>Case builder |

### Fuzzy coding

The affinity of each taxon for each trait category was described using a fuzzy coding approach (Chevenet et al. 1994). In this method, a score from 0 to 3 is assigned to each taxon in the categories as follows: 0 – no taxon affinity for the category; 1 – weak affinity; 2 – moderate affinity; and 3 – high affinity. This technique helps to compensate for different levels of information coming from diverse sources and variations that may exist within species due to the variable requirements of different developmental stages (Chevenet et al. 1994).

To determine the body size of each EPT genus, measurements were taken of the invertebrate linear body lengths (from the head to the end of the abdomen) using a stereomicroscope of ~10% of all EPT organisms sampled from the four HUs studied. Such measurements were then classified into 6 categories (Table 1) (Appendix 4).

# OBJECTIVES AND STRUCTURE OF THE THESIS

From a macroecological perspective, specific evidence of how trait patterns vary along different environmental gradients in different geographical regions would provide useful knowledge about the overall patterns of trait response (Heino et al. 2013). Most past studies of trait-environmental and trait-spatial relationships have focused on streams in different regions and biomes around the world, such as in temperate (e.g., Bêche et al. 2006, Göthe et al. 2017), boreal (e.g., Heino 2005), and tropical forests in Asia (Ding et al. 2017) and South America (e.g., Colzani et al. 2013), but no studies have yet been undertaken in the neotropical savanna region, which is both a biodiversity hotspot and poorly studied region. The characteristics of similar taxa have been shown to differ between different continents (Serra et al. 2017).

The main objective of this thesis was to assess how land cover and land use in natural and human-impacted situations affected the taxonomic and trait compositions of aquatic invertebrate assemblages and trophic relationships and whether neotropical savanna headwater streams behave differently from other streams worldwide. I used stable isotopes, in-stream habitat and landscape data from analyses of satellite imagery, and the taxonomic and trait composition of EPT assemblages to investigate three interrelated sets of questions (Figure 3):

(1) How do the intensity of land use and the associated changes in land cover affect the energy flow and the trophic relationships among benthic macroinvertebrate communities? (Chapter 1).

(2) How do the catchment and local-scale variables contribute to shaping the EPT taxonomic and trait composition? (Chapter 2).

(3) How do EPT assemblages change with human impairment in terms of taxonomic composition, diversity and functional traits? (Chapter 3).

Chapter 1 was published in PlosOne, Chapter 2 was published in Freshwater Biology and the third chapter is under review in an international journal.

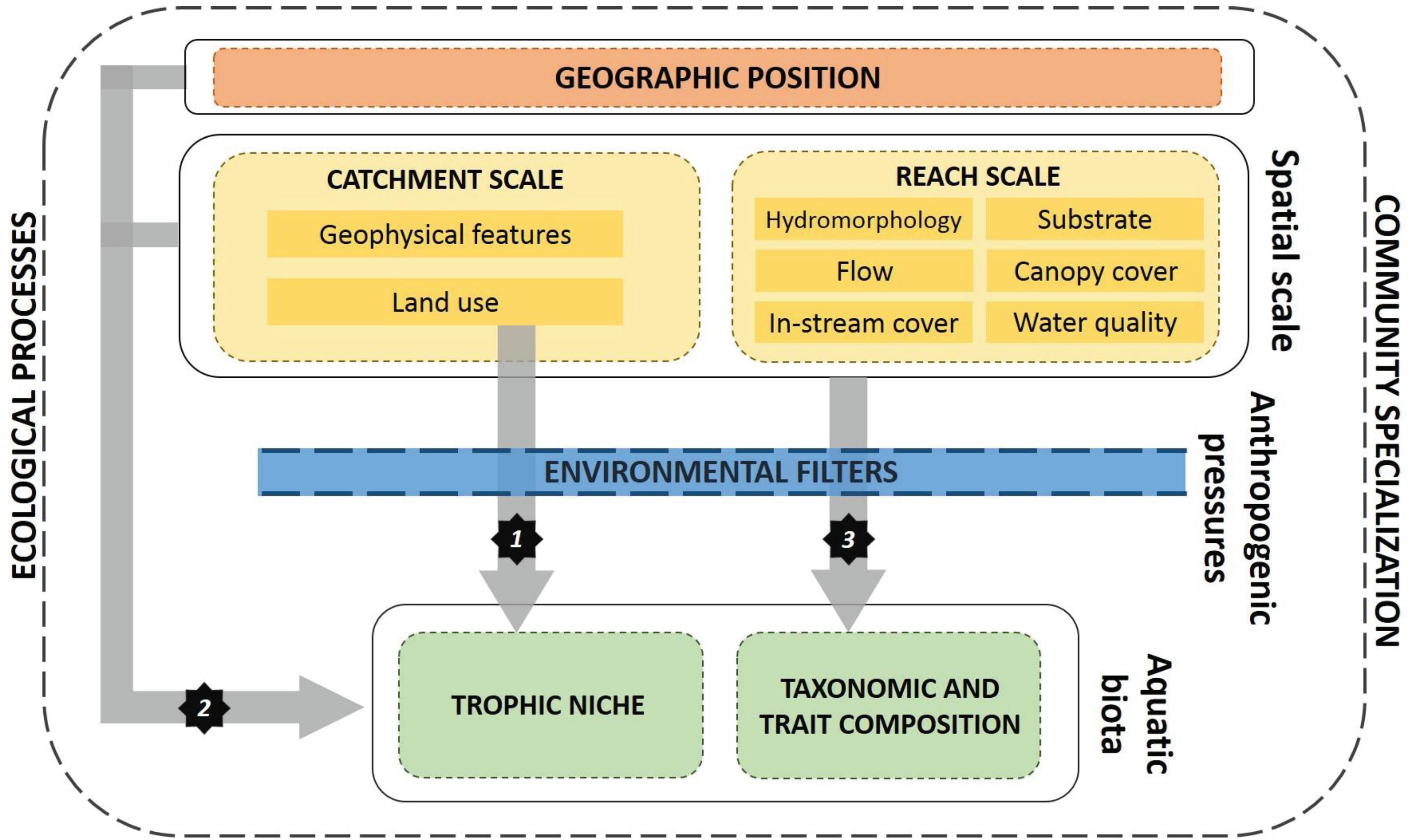


**Figure 3**: Methodological framework representing the overall thesis structure and links among chapters. The numbers 1-3 are related to each chapter of the thesis.

# Chapter I

# Land use influences niche size and the assimilation of resources by benthic macroinvertebrates in tropical headwater streams

Chapter 1 is a version of the following paper: Castro, DMP., Carvalho, DR., Pompeu, PS., Moreira, MZ., Nardoto., Callisto, M. (2016) Land use influences niche size and the assimilation of resources by benthic macroinvertebrates in tropical headwater streams. PLos ONE 11(3):e0150527. doi: 10.1371/journal.pone.0150527

PLOS | ONE

RESEARCH ARTICLE

# Land Use Influences Niche Size and the Assimilation of Resources by Benthic Macroinvertebrates in Tropical Headwater Streams

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## Abstract

It is well recognized that assemblage structure of stream macroinvertebrates changes with alterations in catchment or local land use. Our objective was to understand how the trophic ecology of benthic macroinvertebrate assemblages responds to land use changes in tropical streams. We used the isotope methodology to assess how energy flow and trophic relations among macroinvertebrates were affected in environments affected by different land uses (natural cover, pasture, sugar cane plantation). Macroinvertebrates were sampled and categorized into functional feeding groups, and available trophic resources were sampled and evaluated for the isotopic composition of $^{13}C$ and $^{15}N$ along streams located in the Cerrado (neotropical savanna). Streams altered by pasture or sugar cane had wider and more overlapped trophic niches, which corresponded to more generalist feeding habits. In contrast, trophic groups in streams with native vegetation had narrower trophic niches with smaller overlaps, suggesting greater specialization. Pasture sites had greater ranges of resources exploited, indicating higher trophic diversity than sites with natural cover and sugar cane plantation. We conclude that agricultural land uses appears to alter the food base and shift macroinvertebrate assemblages towards more generalist feeding behaviors and greater overlap of the trophic niches.

## Introduction

Tropical streams are among the most threatened ecosystems in the world [1], especially in developing countries [2]. In recent decades, these environments have been experiencing substantial changes in land use and occupation. Such changes include replacing native vegetation with large-scale agricultural activities and poorly planned urban expansion.

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Those changes in turn have resulted in alarming losses of biodiversity in aquatic ecosystems, especially in tropical streams [1,3]. The Cerrado (neotropical savanna) is the second largest biome in South America (after the Amazon), a biodiversity hotspot [4] and one of the most threatened biomes in the world, mainly because of the replacement of natural vegetation with pasture and row crop agriculture [5,6]. Those agricultural activities currently alter 40% of the native terrestrial plant cover [7] and have reduced or removed the native riparian vegetation, thereby degrading aquatic ecosystem ecological integrity [8].

The replacement, reduction or removal of vegetation cover, especially in riparian areas, leads to the degradation of physical habitat structure, increased sedimentation rates, hydrological changes, and water temperature oscillations [9,10]. These changes directly influence the input of nutrients, allochthonous resources, autochthonous production [10], the quantity and quality of available food resources [9], and may simplify trophic structure and reduce biological diversity [11,12]. Therefore, studies addressing the impacts of changes in vegetation cover on the energy flow and trophic relations in aquatic environments are essential to an understanding of the mechanisms that regulate the ecological integrity of those environments.

In freshwater ecosystems, aquatic invertebrates are the main link between primary producers (e.g., periphyton and aquatic macrophytes) and higher trophic levels (e.g., aquatic vertebrates). By breaking down organic matter, they contribute to litter decomposition and nutrient availability for other organisms [13,14]. Aquatic macroinvertebrates may be classified according to their feeding habits into functional feeding groups (FFG) [15] based on morphological and behavioral characteristics [16]. Those groups include the following: (i) scrapers that feed on organic matter adhered to organic and inorganic substrates (e.g., periphyton, algae and their associated microbiota); (ii) shredders that feed directly on coarse particulate organic matter (CPOM); (iii) gathering-collectors that feed mainly on deposited fine particulate organic matter (FPOM); (iv) filtering-collectors that filter fine suspended organic matter; and (v) predators that feed on whole animals or their parts [14,16].

Macroinvertebrate assemblages are sensitive to environmental conditions and reflect the physical and chemical conditions of the ecosystem [17]. Therefore, analyzing trophic relationships among macroinvertebrates and the energy flow in aquatic ecosystems is required to understand assemblage structure and dynamics and ecosystem functioning [18].

The energy flow and trophic relationships among the organisms in an ecosystem may be assessed using stable isotope analysis (SIA) of carbon (C) and nitrogen (N) [19]. The ratios between stable isotopes of $^{13}C$ and $^{12}C$ (expressed relative to a standard and called $\delta^{13}C$) and of $^{15}N$ and $^{14}N$ (expressed relative to a standard and called $\delta^{15}N$) provide information that incorporates spatio-temporal scales and facilitates the analysis of food assimilation by consumers [20] and the definition of their trophic niches [21,22]. Stable isotope analysis has been an important and advantageous tool in trophic ecology studies [23] to examine resource partitioning [24], ecosystem fluxes of carbon and nitrogen [25], to reconstruct diets [26,27] and to characterize niche properties [22,28].

The $\delta^{13}C$ and $\delta^{15}N$ values in consumers reflect the C and N stable isotope ratios of the food sources [20]. The $^{13}C$ enrichment between food sources and consumers is usually low (0–1‰) [29,30]. Because $\delta^{13}C$ values typically differ among basal sources (e.g., plant material from C3 and C4 plants), $\delta^{13}C$ is used as an indicator of C sources for certain consumers along food chains [18,20]. In contrast, the trophic fractionation of $\delta^{15}N$ usually varies from 2 to 4‰ at each trophic level [29,30], facilitating definition of the total length of the food chain and the position of an organism within it [18,31]. Therefore, the isotopic ratios of $\delta^{13}C$ and $\delta^{15}N$ in animal tissues reflect information on their use of physical habitats and trophic characteristics and are currently used to determine organic matter origin, trophic relationships and niche size and overlap [22,28].

The relative contributions of food resources to the diet of an animal may be calculated using isotope mixing models [32]. However, most of food webs are too complex and the number of food sources exceeds the number of useful isotope tracers by more than one. In this case, the model does not generate exact values for proportional contributions of each source, but instead provides a range of possible contributions or feasible solutions [19]. Recently Bayesian mixing models have been proposed to assess stable isotope data (e.g., [33–36]) through the use of statistical distributions to characterize the uncertainties in food sources, consumer isotopic values, and estimated source contributions [19].

The isotopic C and N signatures of consumers in aquatic ecosystems may vary because of changes in riparian zones, which provide most of the organic matter used by aquatic communities [27]. In addition, riparian vegetation stabilizes stream banks and filters excessive inputs of materials (e.g., fine sediments) and nutrients (e.g., manure and fertilizers used in surrounding plantations) to the waterbodies [9,37]. Therefore, variations in riparian vegetation cover influence the dynamics and structure of aquatic communities (e.g. [38,39]), changing the isotopic composition of resources and consumers. In turn, those isotopic signatures aid comparisons of the ecological processes in riparian zones, identification of the effects of agriculture and deforestation on assemblages, and assessments of the interactions between riparian land cover and water bodies [20,40].

In this study, we evaluated how the energy flow and the trophic relationships among benthic macroinvertebrates were influenced by riparian land uses (natural vegetation, pasture, sugar cane plantation). Based on C and N stable isotope analyses, we compared isotopic niche breadth and the degree of niche overlap among macroinvertebrate trophic groups. We first tested whether anthropogenic activities in areas adjacent to streams can expand the trophic niche of macroinvertebrates and their degree of overlap. Then, we assessed whether anthropogenic land uses in riparian zones were associated with more generalist trophic groups and less specialized trophic groups compared with streams with native riparian vegetation.

## Materials and Methods

### Study area

We studied sites in tributaries of the São Simão Hydroelectric Power Plant Reservoir, located in the sub-basin of the Paranaíba River, southeastern Brazil (Fig 1). The Paranaíba River basin is the second largest drainage basin of the Paraná River basin, corresponding to a drainage area of 223 $km^2$ (25.4% of its area) [27].

Nine 2$^{nd}$- and 3$^{rd}$-order streams (on a 1:100,000 scale map) located in the states of Minas Gerais and Goiás were selected from 110 previously investigated streams [41]. We used a hierarchical and spatially balanced sampling algorithm (e.g., [8]) proposed by Olsen & Peck [42] to select those 110 sampling sites. The nine streams were selected according to their land use, where three were located in pasture areas, three were located in sugar cane plantation areas, and three were representative of natural riparian vegetation. A continuous segment proportional to the width of the stream (defined as 40 times the mean stream width, minimum of 150 meters) was sampled in each stream. We sampled available trophic resources and aquatic macroinvertebrates during the dry season (September) of 2012. We evaluated the land use of the riparian zones of the sites through use of satellite images [43]. For the nine sites, we determined the percentages of natural cover, pasture, and sugar cane plantations in a 150 m radius buffer around the upstream limit of each site [27]. To illustrate the variation in the physical habitat structure of streams with different land uses, environmental characteristics of each site were quantified (S1 Table) and are detailed in Carvalho et al. [27].

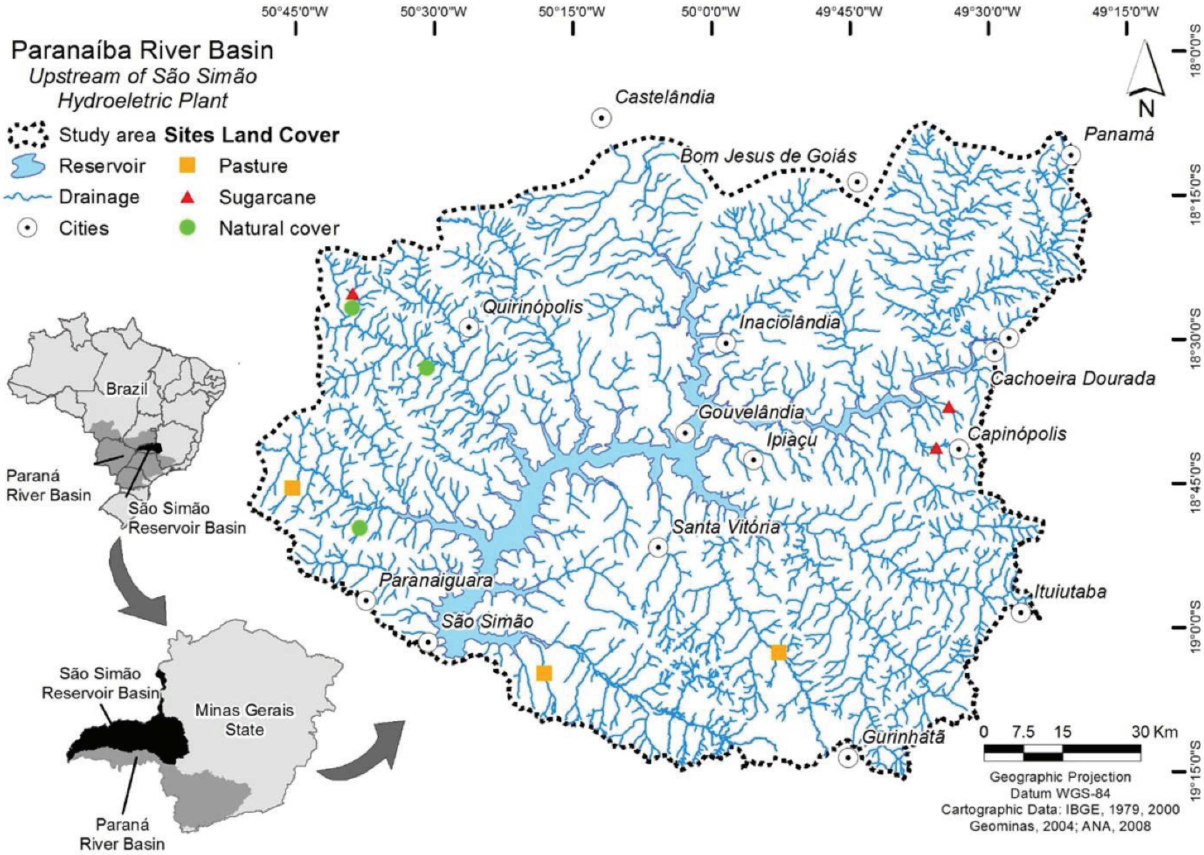


**Fig 1. Locations of the nine stream sites selected according to their land use and study area in the states of Minas Gerais and Goiás, Brazil.**

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## Sample collection and processing

Each stream was subdivided into five equally sections. We collected five independent samples (one per section) of benthic macroinvertebrates from each site, along with five independent samples of food resources: CPOM, FPOM, filamentous algae, periphyton, leaves of the riparian vegetation (forest, pasture, sugar cane) and suspended particulate organic matter (seston). Only one site had aquatic macrophytes; therefore, macrophytes were not considered as resources in the analyses. We collected algae, CPOM, periphyton, FPOM, leaves of native riparian vegetation and seston from sites in all three types of riparian environments, whereas pasture grasses were collected only in the pasture environment and sugar cane leaves only in the sugar cane environments (S2 Table).

We collected benthic macroinvertebrates assemblages through use of D-frame kick-nets (30 cm aperture, 500 mm mesh), following a systematic zig-zag pattern along the segments defined [44], covering all different substrates and habitats in each site. Five sample units (0.09 $m^2$ each) were taken per stream, one per section, totaling 0.45 $m^2$ per site. All invertebrates sampled were stored on ice and after 2 days processed in laboratory. In the laboratory, the organisms collected were washed in distilled water, taxonomically identified [16,45,46] and classified into

**Table 1. Taxa used in each trophic group analyzed.** The letter "n" indicates the number of samples. Different numbers of invertebrates were used for each sample to reach a minimal amount of material for isotope analysis.

| Consumers | Natural cover | (n) | Pasture | (n) | Sugar cane | (n) |
|---|---|---|---|---|---|---|
| **Collectors** | Chironomidae | 4 | Baetidae | 2 | Chironomidae | 4 |
| | Elmidae (larvae) | 9 | Chironomidae | 3 | Elmidae (larvae) | 10 |
| | Leptohyphidae | 2 | Elmidae (larvae) | 6 | Leptohyphidae | 1 |
| | | | Leptohyphidae | 1 | | |
| **Filter-feeders** | Hydropsychidae | 11 | Hydropsychidae | 11 | Hydropsychidae | 11 |
| | Philopotamidae | 3 | Leptoceridae | 3 | Simuliidae | 4 |
| | Simuliidae | 1 | Simuliidae | 1 | | |
| **Shrimp-shredders** | Palaemonidae | 13 | Palaemonidae | 7 | – | |
| **Insect-shredders** | | | Calamoceratidae | 2 | Calamoceratidae | 1 |
| | – | | Odontoceridae | 1 | Odontoceridae | 1 |
| | | | Pyralidae | 3 | Pyralidae | 1 |
| **Scrapers** | Elmidae (adult) | 6 | Ampullariidae | 2 | Elmidae (adult) | 6 |
| | Leptophlebiidae | 7 | Elmidae (adult) | 7 | Leptophlebiidae | 4 |
| | Psephenidae | 2 | Leptophlebiidae | 3 | Planorbidae | 4 |
| **Predators** | Megaloptera | 6 | Megaloptera | 3 | Belastomatidae | 1 |
| | Naucoridae | 2 | Naucoridae | 3 | Megaloptera | 3 |
| | Odonata | 6 | Odonata | 8 | Naucoridae | 2 |
| | Perlidae | 1 | Perlidae | 1 | Odonata | 8 |
| | | | | | Perlidae | 1 |

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functional feeding groups: predators, scrapers, shredders, gathering-collectors (hereafter "collectors") and filtering-collectors (hereafter "filter-feeders") [47–49]. Shredders were divided into insect-shredders (Insecta) and shrimp-shredders (Crustacea) because shrimp-shredders may have a generalist omnivore behavior, feeding on multiple resources [50]. Each macroinvertebrate functional feeding group was considered a consumer, whereas the periphyton, filamentous algae, seston, FPOM, CPOM and vegetation leaves were considered resources. The other macroinvertebrate functional feeding groups were considered as resources for predators. It was not always possible to obtain five samples of each functional feeding group or food resources in each site (e.g. just three samples of insect-shredders in the pasture areas), therefore, a total 232 food resource samples and 202 macroinvertebrate samples (among 270 possible: 9 sites x 5 samples x 6 resources / FFG) were obtained and analyzed. The last author, MC, has a permanent license to collect aquatic invertebrates (10365–2) in the entire Brazilian territory provided by IBAMA/Sisbio, in accordance with federal law and the regulations of the Brazilian Environmental Ministry. The sampling sites were private, and permission from the owner or manager was obtained prior to sampling. None of the sampled species was protected by Brazilian law or red-listed.

After identifying and classifying in functional feeding groups, organisms were then oven-dried at 60° for 48 h, ground to a fine and homogeneous powder using a mortar and pestle and then stored in Eppendorf tubes for subsequent analysis of their isotopic compositions. Collector, filter-feeder, predator and scraper consumers were found at sites in all three types of riparian environments, whereas shrimp-shredders were not found in the sugar cane sites and insect-shredders were not found in natural cover sites. Each FFG sample was composed of only one specific family and different numbers of invertebrates were used for each sample to reach a minimal amount of material for isotope analysis (Table 1).

Sampling of resources was carried out in parallel to macroinvertebrates collecting along the segments defined in each site. Periphyton was collected by scraping rocks with a brush (three rocks per segment) and placing the material in a plastic container with distilled water [44]. Seston was collected with a phytoplankton net (0.45 mm) set for 1 min upstream of each site. The samples were stored in coolers with ice after sampling and then transported to the laboratory, where they were kept frozen until processing. In the laboratory, the samples were filtered using a filtration apparatus coupled to a vacuum pump with calcined glass fiber filters (Millipore 45 $\mu m$). Filamentous algae was collected manually in each segment, stored in plastic containers in ice coolers and then frozen. The FPOM samples were collected from sediment deposits revolving the sediment and passing a phytoplankton net (0.45 mm) in the material in suspension. After the material was stored in plastic containers and then frozen. Pasture leaves, sugar cane leaves, and leaves of the natural riparian vegetation were manually collected along the segments delimited in each sampled stream, with the most common species being prioritized at the site. Species priorization was made in compliance with the most common and abundant species in each segment. Five leaves were then collected from each of the five most common plants. We obtained samples of native riparian vegetation even at sugar cane and pasture sites. The CPOM was randomly collected from leaf litter deposits in the streams. All leaves were then stored in paper bags and kept in plant presses until processing in the laboratory. In the laboratory, all resource samples were dried in an oven at 60°C for 48 h and then ground with a mortar and pestle and stored in Eppendorf tubes. Approximately 2–5 mg of dried animal tissue and 5–10 mg of resources were used for the isotopic analysis.

All samples were sent to the Laboratory of Isotope Ecology of the Center for Nuclear Energy in Agriculture (Centro de Energia Nuclear na Agricultura—CENA), University of São Paulo (Universidade de São Paulo), Piracicaba, Brazil, for determination of the $\delta^{13}C$ and $\delta^{15}N$ values. Analyses of isotopic ratios were processed through sample combustion under a continuous flow of ultrapure helium in an elemental analyzer (Carlo Erba, CHN– 1110) that was coupled to a Thermo Finnigan Delta Plus mass spectrometer for isotopic ratios. The results were expressed in delta notation ($\delta$), in parts per thousand (‰), relative to standard international references (V-PDB–Vienna Pee Dee Belemnite for C and atmospheric air for N), and were calculated using the following equation:

$$\delta X = [(R_{Sample}/R_{Standard}) - 1] \times 10^3$$

where X is $^{13}C$ or $^{15}N$ and R represents the isotopic ratios $^{13}C/^{12}C$ or $^{15}N/^{14}N$ [25]. The analytical precision values estimated by replicates of the working standards of $\delta^{13}C$ and $\delta^{15}N$ were ±0.10 and ±0.11‰, respectively.

When using stable isotope data to reconstruct animal diets, the resources must have isotopically distinct signatures to ensure a sensitive interpretation of the results. If they are not significantly different and are somehow logically related (e.g., same taxon or trophic group), the resources may be combined and represented in the mixing model by a single set of isotopic values [51]. The $\delta^{13}C$ values of samples of the riparian vegetation and CPOM deposited in the streams were very similar among the environments; therefore, the values of the riparian vegetation samples were excluded from the analyses. The FPOM and the seston samples also had similar $\delta^{13}C$ values and were grouped; hereafter, those groups are called fine particulate organic matter (FPOM).

## Data analysis

We used the SIAR package for the analysis of stable isotopes [34,52] in R [53], to determine the relative contribution of each food resource available for the macroinvertebrates. Differences in the isotopic ratios of the food resources and consumers among environments were tested using one-way analyses of variance (ANOVAs) when the normality and homoscedasticity assumptions were met. The nonparametric Kruskal-Wallis test was used for data with non-normal distribution.

In the partition analysis, the food resources of each land use category were considered separately to determine the contribution of each resource for the consumers. The mean value of the food resources in all categories was used to visually represent the spatial distribution of the taxa according to their $\delta^{15}N$ and $\delta^{13}C$ values. The fractionation values used were 0.5 ± 0.13‰ for C and 2.3 ± 0.18‰ for N [29]. The trophic structure of the benthic macroinvertebrate assemblage was described for each land use using the metrics proposed by Layman et al. [21]. Those metrics use the stable isotope ratios of the different components of the food chain to describe the niche and trophic structure of the assemblage, providing information on the trophic diversity and redundancy within a food chain [54]. However, one of the limitations of using the metrics originally proposed by Layman et al. [21] is that those metrics are sensitive to the sample size and may not be comparable between studies and different sites. A second limitation is that the metrics, when applied to an assemblage, do not incorporate any natural variability within the system and, thus, provide only a point estimate of each metric [55].

A Bayesian approach recently developed for the aforementioned metrics enables the distribution of the sampling errors of the means estimated for the members of the assemblage. Using that approach, we generated a posterior distribution of the estimates of those metrics, providing a measure of uncertainty and allowing statistical comparisons among assemblages [54,55]. Thus, we calculated the five macroinvertebrate assemblage metrics through use of the Stable Isotope Bayesian Ellipses package in R (SIBER; [55]): 1) $\delta^{13}C$ range ($CR_b$) and $\delta^{15}N$ range ($NR_b$), which together indicate the variety of resources exploited by the assemblage. 2) The mean distance to centroid ($CD_b$), which is the mean Euclidian distance of each assemblage component to the centroid, indicating the trophic diversity within the food chain. 3) The mean nearest neighbor distance ($MNND_b$), which is the mean Euclidean distance from each group to its nearest neighbor in the $\delta^{13}C$-$\delta^{15}N$ bi-plot space (plotted based on their mean stable isotope signatures), an estimate of the total density and clustering within the assemblage. Low MNND values indicate an increase in trophic redundancy, i.e., the occurrence of many groups with similar trophic levels. 4) The standard deviation of the nearest neighbor distance (SDNND), which measures the uniformity of the groups in bi-plot space, where lower SDNND values suggest a more uniform trophic niche distribution [21]. We calculated the metrics originally proposed by Layman et al. [21] and reformulated in a Bayesian framework by Jackson et al. [55] for each site, enabling a comparison of the structure and trophic ecology of each land use. Results were then compared between land uses based on the visual analysis of the credible intervals (CIs) of the Bayesian implementation of the Layman metrics. We estimated the standard ellipse area ($SEA_c$, in ‰$^2$) as a bivariate measure of the central mean of the isotopic niche [55]. The $SEA_c$ enables calculating the degree of niche overlap of the assemblage (in %, where 100% indicates total overlap) and may be used as a quantitative measure of diet similarity among the different groups [56]. All measures were bootstrapped (n = 10,000, indicated by the letter "*b*") to compare groups with different sample sizes. A small sample size correction (indicated by the subscript letter "*c*") was applied to increase the accuracy of the comparisons, enabling the comparison of niches of groups with different sample sizes [55].

## Results

### Differences in the isotopic signatures of resources and consumers among land uses

The isotopic signatures of the food resources studied varied widely among and within land use types (Fig 2). In the natural cover sites, the periphyton and FPOM exhibited the highest $\delta^{13}C$

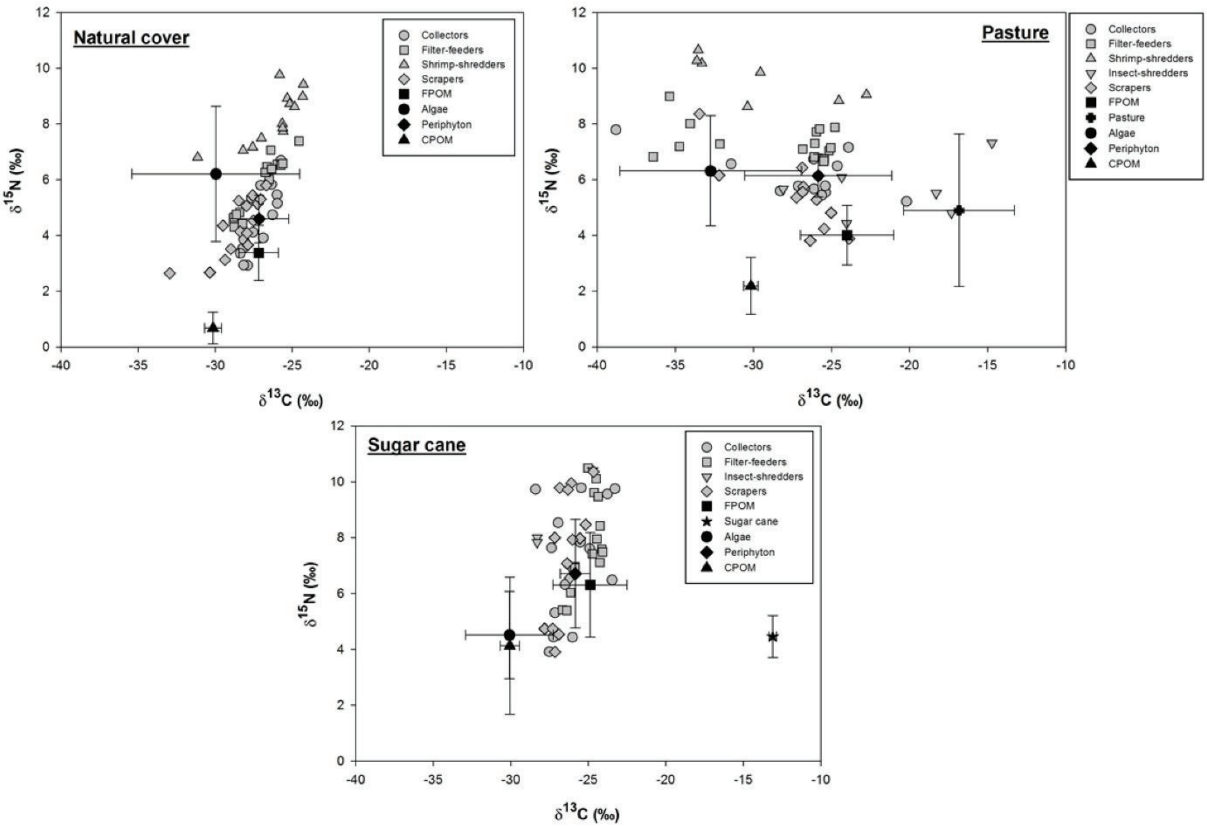


**Fig 2. Representation of the $\delta^{13}$C and $\delta^{15}$N of food resources (mean ± SD) and consumers in sites with different riparian land uses.**

doi:10.1371/journal.pone.0150527.g002

values, whereas CPOM had the lowest values. The pasture and sugar cane plants exhibited the highest $\delta^{13}$C values, whereas CPOM and algae had the lowest $\delta^{13}$C values (Fig 2). CPOM had the lowest $\delta^{15}$N values in all land uses, algae exhibited the highest $\delta^{15}$N values in the natural cover and pasture sites, and periphyton had the highest $\delta^{15}$N values in sugar cane sites (Fig 2).

The consumers also exhibited wide variations in isotopic composition among land uses and functional feeding groups (Figs 2 and 3). In the natural cover sites, shrimp-shredders had the highest $\delta^{13}$C and $\delta^{15}$N values, whereas scrapers had the lowest $\delta^{13}$C and $\delta^{15}$N values. In pasture sites, insect-shredders had the highest $\delta^{13}$C values, whereas shrimp-shredders and filter-feeders had the lowest $\delta^{13}$C values. Also shrimp-shredders exhibited the highest $\delta^{15}$N values, whereas scrapers and insect-shredders had the lowest $\delta^{15}$N values (Figs 2 and 3). In sugar cane sites, predators (on average) exhibited the highest $\delta^{13}$C and $\delta^{15}$N values (Fig 3, S2 Table), whereas the lowest $\delta^{13}$C values were recorded for insect-shredders, and the lowest $\delta^{15}$N values were recorded for collectors and scrapers (Fig 3).

## Feeding contribution in each stream category

There was wide variation in the proportion of items assimilated by the functional feeding groups among the three land uses assessed. Sites with natural vegetation cover supported

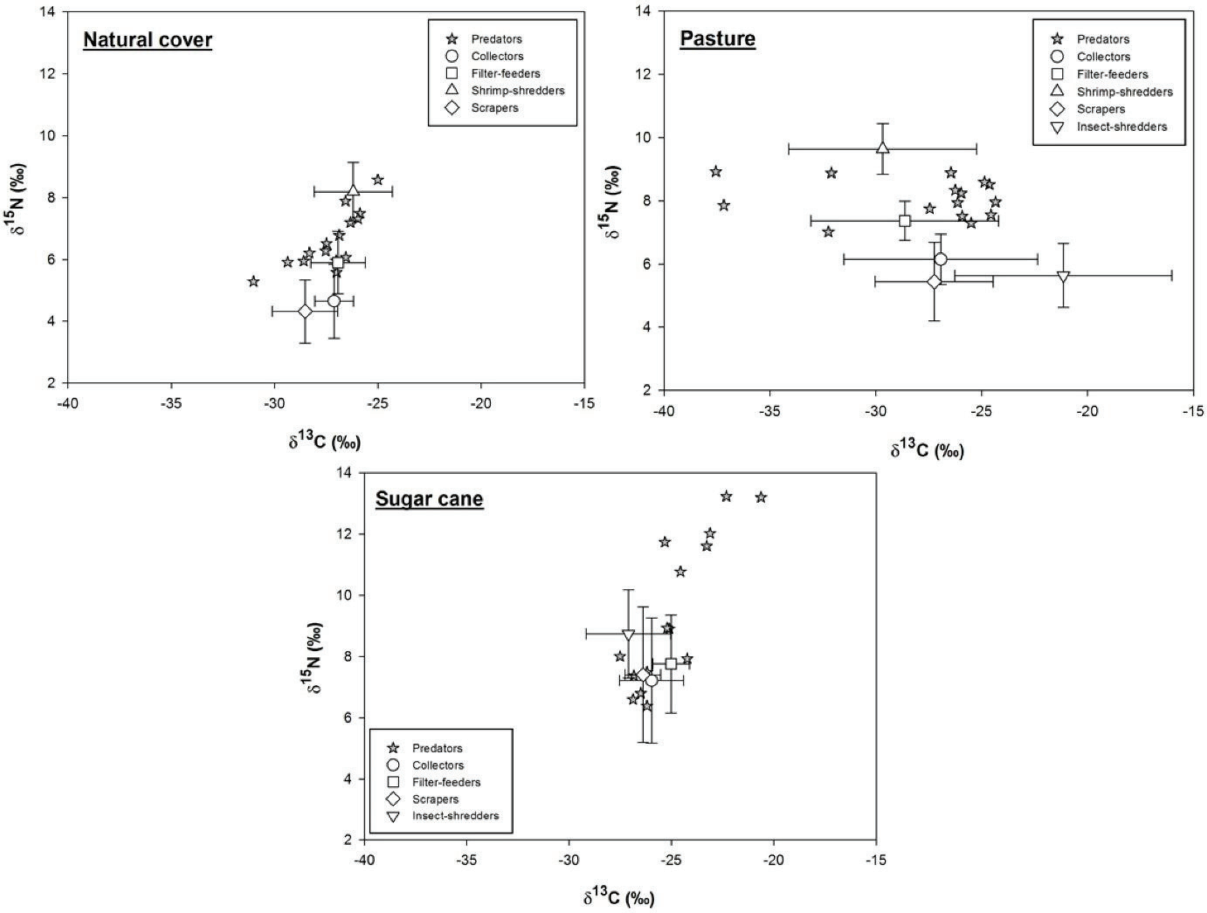


**Fig 3. Representation of the $\delta^{13}C$ and $\delta^{15}N$ of prey (mean ± SD) and predators in sites with different riparian land uses.**

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macroinvertebrate assemblages with more specialist trophic habits. Collectors and filter-feeders assimilated 44–49% FPOM, scrapers assimilated 57% CPOM, and shrimp-shredders assimilated 83% algae and periphyton as opposed to CPOM (Fig 4A, S3 Table).

Some functional groups showed greater specificity for certain food resources in pasture streams. Collectors and scrapers assimilated 38–49% CPOM, whereas the filter-feeders assimilated 58% algae and periphyton. The insect-shredders assimilated nearly equal amounts of CPOM, FPOM, and pasture grasses. However, the shrimp-shredders continued assimilating mainly algae and periphyton (Fig 4B, S3 Table).

All functional feeding groups had more generalist trophic habits in the sugar cane sites, and none assimilated a single resource in particular. In addition, the sugar cane leaves contributed only 7–15% to the diets of macroinvertebrates (Fig 4C, S3 Table).

Predators had a pattern similar to that of the other trophic groups in the sugar cane sites, with no preferentially assimilated resource. Predators assimilated 40% and 53% scrapers in pasture sites and sites with natural cover, respectively (Fig 5, S4 Table).

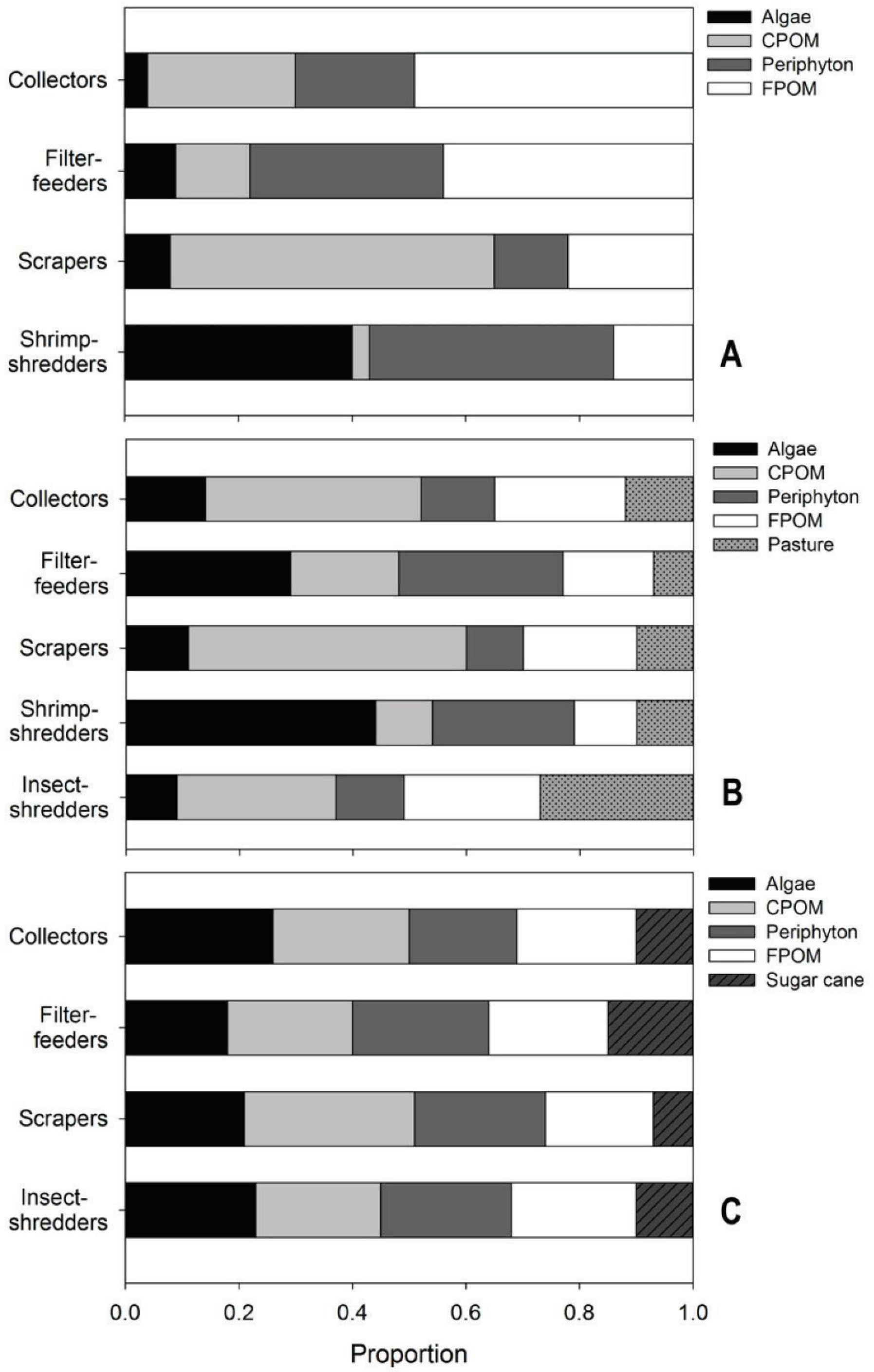

Collectors
Filter-feeders
Scrapers
Shrimp-shredders
Algae
CPOM
Periphyton
FPOM
A
Collectors
Filter-feeders
Scrapers
Shrimp-shredders
Insect-shredders
Algae
CPOM
Periphyton
FPOM
Pasture
B
Collectors
Filter-feeders
Scrapers
Insect-shredders
Algae
CPOM
Periphyton
FPOM
Sugar cane
C
0.0
0.2
0.4
0.6
0.8
1.0
Proportion

**Fig 4.** Means of the proportions of food resources used by each trophic group in each land use category based on stable isotopes analysis in R (SIAR) output: (A) natural cover, (B) pasture, and (C) sugar cane.

doi:10.1371/journal.pone.0150527.g004

## Spatial differences in trophic structure

The standard ellipses ($SEA_c$) based on the isotope ratio of trophic groups of macroinvertebrates differed in size, shape and position in the $\delta^{13}C$ vs $\delta^{15}N$ bi-plot space (Fig 6). The groups with the lowest $SEA_c$ values occurred in the sites with natural vegetation, followed by the sugar cane and pasture sites, which exhibited the highest $SEA_c$ values.

Sites with natural riparian vegetation cover exhibited very little overlap of isotopic niches (i.e., overlap of standard ellipse areas) of the macroinvertebrate feeding groups (Fig 6A). Small overlaps were observed between the collectors, scrapers and filter-feeders. The shrimp-shredders exhibited the largest $SEA_c$ (3.83‰$^2$), followed by scrapers (3.29‰$^2$), predators (3.01‰$^2$), collectors (2.26‰$^2$) and filter-feeders (1.42‰$^2$).

Considerable niche overlapping was observed among feeding groups in pasture sites (Fig 6B), especially between collectors and insect-shredders (30.7%) and scrapers (29.3%), and between filter-feeders and predators (25.4%). The other groups exhibited little or no niche overlap. The greatest $SEA_c$ values were observed for the insect-shredders (19.2‰$^2$), followed by the collectors (9.67‰$^2$), predators (9.04‰$^2$), shrimp-shredders (8.89‰$^2$), filter-feeders (8.8‰$^2$) and scrapers (6.9‰$^2$).

The greatest niche overlaps among groups were observed in sugar cane sites (Fig 6C). In those sites, the niches of all feeding groups evaluated overlapped, with the highest overlap

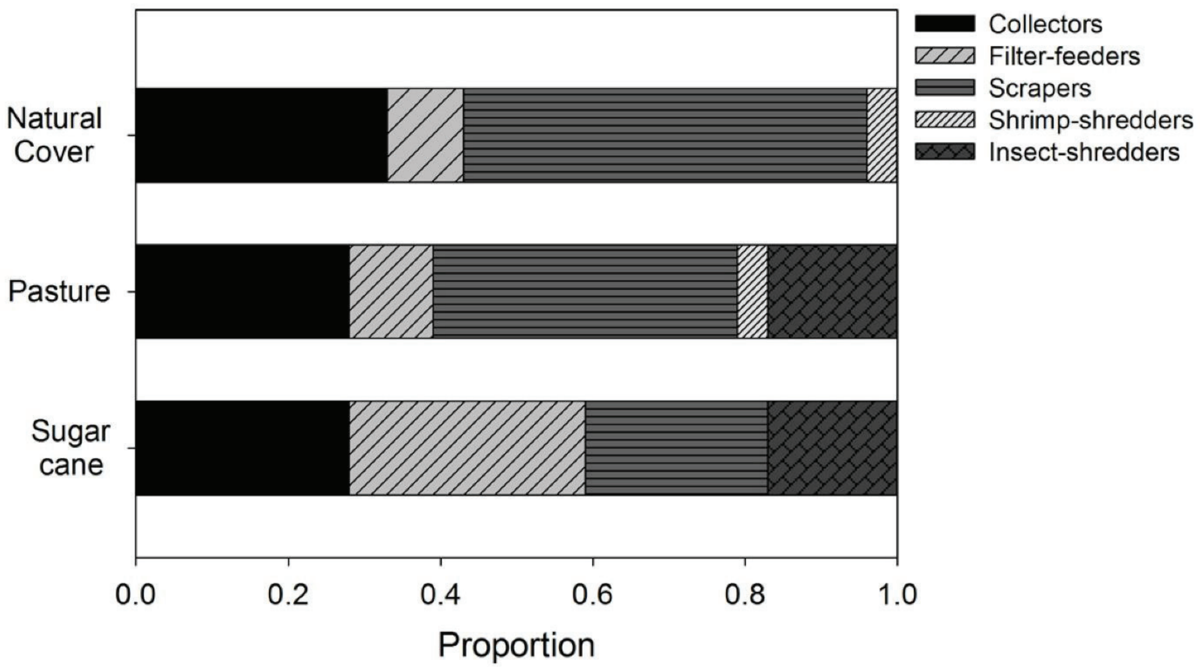
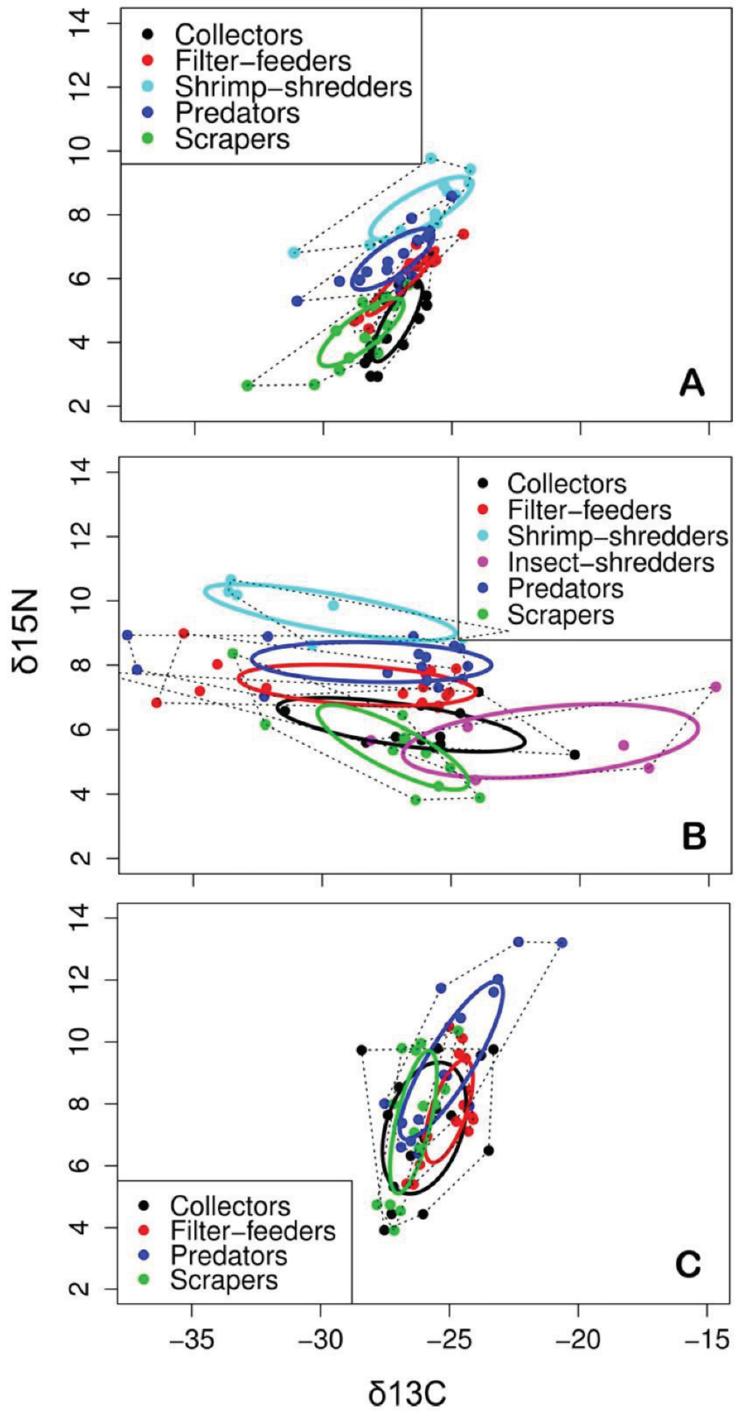



**Fig 5. Means of the proportions of macroinvertebrate prey consumed by predators in each land use category based on stable isotopes analysis in R (SIAR) output.**

doi:10.1371/journal.pone.0150527.g005



Collectors
Filter−feeders
Shrimp−shredders
Predators
Scrapers
A
Collectors
Filter−feeders
Shrimp−shredders
Insect−shredders
Predators
Scrapers
B
Collectors
Filter−feeders
Predators
Scrapers
C
δ15N
δ13C
−35
−30
−25
−20
−15

**Fig 6. Standard ellipse areas (SEA, solid lines), representing the core isotopic niche space of the macroinvertebrate feeding groups, as determined through SIBER models for the three land use categories: (A) natural cover, (B) pasture and (C) sugar cane.** The dashed lines delimit the total area of the macroinvertebrate assemblages of each land use category.

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values observed between collectors and scrapers (45.9%) and collectors and filter-feeders (31.4%). The niches of predators overlapped with the niches of all other groups, whereas the filter-feeders and scrapers exhibited the least niche overlap (24.7%). The collectors had the largest $SEA_c$ (10.19‰$^2$), followed by predators (8.23‰$^2$), scrapers (4.96‰$^2$) and filter-feeders (3.71‰$^2$). Calculation of the $SEA_c$ for insect-shredders in sugar cane sites was not possible because we obtained only three samples of this group.

The trophic niche metrics of the macroinvertebrate communities varied among land uses. Pasture sites had significantly greater ranges of resources exploited ($NR_b$ and $CR_b$), trophic diversity ($CD_b$), and trophic redundancy ($MNND_b$) and showed significantly lower group uniformity ($SDNND_b$) (Table 2). In contrast, sugar cane sites exhibited the lowest values for all metrics and sites with natural cover had intermediate values that did not overlap with sugar cane sites except for $SDNND_b$ (Table 2).

## Discussion

The use of stable isotopes along with analytical techniques, such as the Bayesian approach, allowed (1) identification of the main resources consumed by benthic macroinvertebrates and (2) assessment of how the different land uses affected resource availability and trophic dynamics in tropical streams. Our hypotheses were corroborated because we observed macroinvertebrate assemblages with wider trophic niches and greater niche overlap in altered sites and greater resource specialization in sites with natural vegetation.

All trophic groups and virtually all resources evaluated had higher $\delta^{15}N$ values in sugar cane and pasture sites. Nutrients from agriculture and cattle strongly affect the waterbodies and may have been responsible for the high $\delta^{15}N$ values found in those streams. On sugar cane plantations, vinasse, a byproduct of ethanol distillation, is the main fertilizer used, whereas chemical fertilizers and livestock manure are the main sources of residues and nutrients in pastures [27]. Fertilizers increase nitrification, leading to soil $^{15}N$ enrichment [57]. Agricultural residues usually have high $\delta^{15}N$ ratios [58], and most are carried into waterbodies and incorporated into food webs, thus changing the $\delta^{15}N$ available in food resources and consumers [59,60].

Although we categorized the groups *a priori*, macroinvertebrates had more generalist feeding habits at pasture and sugar cane sites, whereas more specialization occurred in macroinvertebrate assemblages of sites with natural riparian vegetation. Benstead & Pringle [61] reported similar results in a comparison of sites with preserved and deforested vegetation in Madagascar. They observed a simplification of the aquatic macroinvertebrate assemblages associated with a loss of specialist taxa associated with changes in the relative importance of the basal food resources. Therefore, we believe that land use changes lead to the selection of more generalist organisms and the elimination of more specialized organisms.

**Table 2. Layman stable isotope metrics (mean and 95% credible intervals) for each land use category: $NR_b = \delta^{15}N$ range; $CR_b = \delta^{13}C$ range; $CD_b$ = mean distance to centroid; $MNND_b$ = mean nearest neighbor distance; and $SDNND_b$ = standard deviation of mean distance to centroid.**

| Land use | $NR_b$ | $CR_b$ | $CD_b$ | $MNND_b$ | $SDNND_b$ |
|---|---|---|---|---|---|
| Natural cover | 3.93 (3.68–4.19) | 2.39 (1.96–2.79) | 1.42 (1.33–1.53) | 1.28 (1.15–1.40) | 0.54 (0.37–0.69) |
| Pasture | 4.35 (4.01–4.67) | 9.05 (7.47–10.5) | 2.79 (2.46–3.09) | 2.21 (1.92–2.49) | 1.75 (1.16–2.25) |
| Sugar cane | 2.45 (0.89–2.95) | 1.70 (1.41–1.97) | 1.08 (0.90–1.25) | 1.07 (0.89–1.25) | 0.52 (0.26–0.73) |

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We found some unexpected results in our study; for example, scrapers assimilated more CPOM than periphyton, a result found in pasture and natural vegetation sites. According to Marchese et al. [62], who observed a high contribution of CPOM to chironomids and oligochaetes, this resource is highly colonized by bacteria, protozoa and algae, which may explain the preference for it. However, it is important to highlight that the classification of organisms into functional feeding groups is primarily related to morphology, feeding habits, or food acquisition and not to the food type per se [14]. Future studies should assess whether macroinvertebrate groups/ guilds with wider trophic niches contain more generalists consuming a wide variety of food types or whether the organisms specialize in a different but narrower ranges of food resources [28].

In contrast with observations made for some fish species in the same region [27] and in other sites [10], in which was observed assimilation of sugar cane and grasses, these food resources were barely assimilated by the trophic groups evaluated. Although the FPOM was slightly richer in $^{13}$C in pasture and sugar cane sites, its contribution to the trophic chain was very low. The C4 plants (grasses in general, such as pasture and sugar cane) are considered to have low nutritional quality compared with C3 plants and are little used by aquatic consumers in many cases, either because of their physical or chemical characteristics that reduce consumption or because consumers are able to select other higher-quality resources [63]. Although present in large amounts at the pasture and sugar cane sites, little C4 plant material entered the food chain through aquatic macroinvertebrates. Bunn et al. [64] and Martinelli et al. [65] also found that few C4 resources were incorporated into the trophic chain in anthropogenically altered sites, despite representing >50% of the detritus in the systems. This reduced contribution of C4 resources into aquatic trophic chains shows how the conversion of natural riparian vegetation into sugar cane plantations and pastures has the potential to alter the trophic dynamics and functional organization of aquatic communities, leading to substantial changes in stream ecosystem functions.

Pasture sites had autochthonous resources (algae and periphyton) with the widest $\delta^{13}$C and $\delta^{15}$N ranges. This wider range may result from reduced riparian canopy cover and, consequently, higher light input, promoting higher diversity and abundance of algae and periphyton species. Similar results have been reported by Turner & Edwards [66], where the producers (algae) had more widely dispersed $\delta^{13}$C and $\delta^{15}$N values. They argued that this variation might result from greater taxonomic diversity of the producers, which could lead to greater diversity in C and N metabolism.

Consumers from streams with natural riparian vegetation had the narrowest isotopic niches and the lowest niche overlaps. This pattern indicates that the macroinvertebrate functional groups in those sites had more selective feeding habits with a lower overlap of trophic niches and, consequently, less competition for resources. In their natural state, wooded riparian zones are effective in preserving the ecological integrity and trophic dynamics of aquatic ecosystems. Land use changes and the consequent shifts in the input of allochthonous nutrients and autochthonous production can reduce the balance between functional feeding groups [67] and, widen their trophic niches.

The isotopic metrics calculated for the assemblages described in this study were based on the mean $\delta^{13}$C and $\delta^{15}$N values of multiple individuals for each group in a trophic web, and such intraspecific variation was not considered in this analysis (i.e. species within the same FFG) [21]. The highest mean $dNR_b$ and $dCR_b$ values observed in the pasture sites indicate that macroinvertebrates use a wider range of the available food sources in this environment, especially in contrast with the sugar cane sites. This result is consistent with the $SEA_c$ values, which were highest in pasture sites. The highest mean $CD_b$ value was also observed in pasture sites, indicating higher trophic diversity at those sites. The highest mean $MNND_b$ values were observed for pasture sites, indicating low trophic redundancy. However, the highest $SDNND_b$ values were also observed in the pasture sites, suggesting the existence of a less uniform trophic niche distribution, despite the low trophic redundancy. This is most likely a result of the greater availability of periphyton and algae in this environment, which are resources with wider $\delta^{13}C$ ranges and which are used by many consumers. According to Layman et al. [21], $MNND_b$ and $SDNND_b$ increase because consumers have more distinct trophic positions (greater distance among consumers in isotopic space).

Another noteworthy result is the occurrence of the crustacean, *Macrobrachium amazonicus*, considered a shrimp-shredder in this study, which is an alien species in the region found in pasture and in natural cover sites. The isotopic niche ($SEA_c$) of shrimp-shredders was one of the highest compared with the other functional groups in those land uses. However, the niche of shrimp-shredders did not overlap with the others, suggesting that this group is exploiting resources that would otherwise not be fully exploited by the native fauna. In addition, the shrimp-shredders were the group least preyed upon, with virtually no contribution to predators. Recently in a global evaluation of the consequences of non-native species on the isotopic structure of freshwater fish communities, Sagouis et al. [68] found that communities in lotic ecosystems containing non-native species had a larger total isotopic niche than communities without non-native species and those non-native species were mainly located at the edges of the isotopic niche. Thus, we highlight the importance of studies assessing how invasive alien species are directly competing for resources with native species or not (e.g., [56,69,70]), where the comparison of isotopic niches and assimilated items may be important tools.

We conclude that land use changes, such as sugar cane culture and livestock pasturing, may lead to benthic macroinvertebrate assemblages with more generalist feeding behaviors and higher trophic niche overlap. In addition, our results reinforce the idea that stable isotope analysis is a relevant tool for biomonitoring and evaluating the effects of land use changes on the dynamics and functioning of tropical streams.

## Supporting Information

**S1 Table. Physical characteristics, land use and environmental variables calculated to the nine streams in the three land use categories.** The numbers 1, 2 and 3 correspond to each of the three streams sampled in each land use category (See Fig 1). Order = rank of the stream orders according to Strahler; Veg. cover = Vegetation Cover. All environmental variables were calculated according to the proportion in which they occur in each assessed stream.
(DOCX)

**S2 Table. Mean ± S.D. isotopic signatures of resources and consumers sampled in the three land use categories.** The letters *a* and *b* indicate which signatures are different according to *post hoc* test. The letter "n" indicates the number of replicates used in each group analysis.
(DOCX)

**S3 Table. Stable isotope analysis in R (SIAR) results of the food source proportions in the diet of the functional trophic groups (FTG) (95% confidence interval).**
(DOCX)

**S4 Table. Stable isotope analysis in R (SIAR) results of the prey proportions in predator diets (95% confidence interval).**
(DOCX)

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## Author Contributions

Conceived and designed the experiments: DMPC DRC PSP MC. Performed the experiments: DMPC DRC MZM. Analyzed the data: DMPC DRC. Contributed reagents/materials/analysis tools: MZM. Wrote the paper: DMPC DRC PSP MZM GBN MC.

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**S1 Table: Physical characteristics, land use and environmental variables for nine streams for three categories of land use.** The numbers 1, 2 and 3 correspond to each of the three streams sampled in each land use category (See Figure 1). Order = rank of the stream orders according to Strahler; Veg. cover = Vegetation Cover. All environmental variables were computed in terms of their proportion in each assessed stream.

| Streams | | Characteristics of streams | | | | Land use | | | | Environmental variables | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Altitude (m) | Order | Mean depth (m) | Mean width (m) | Natural cover (%) | Pasture (%) | Cane (%) | Others (%) | Fine subst. (%) | Veg. cover (%) | Rapid flow (%) | Aquatic plant (%) | Leaf banks (%) | Algae (%) |
| Natural cover | 1 | 482 | 2nd | 0.20 | 3.42 | 53.14 | 0 | 46.86 | 0 | <0.01 | 0.94 | 0.69 | <0.01 | 0.17 | <0.01 |
| | 2 | 434 | 3th | 0.19 | 7.29 | 39.13 | 57.87 | 0 | 3.00 | <0.01 | 0.47 | 0.46 | <0.01 | 0.14 | <0.01 |
| | 3 | 509 | 3th | 0.19 | 7.35 | 50.86 | 49.14 | 0 | 0 | <0.01 | 0.90 | 0.51 | <0.01 | 0.18 | <0.01 |
| Sugar cane | 1 | 516 | 2nd | 0.23 | 3.98 | 14.05 | 36.56 | 45.81 | 3.59 | 0.01 | 0.73 | 0.38 | <0.01 | 0.11 | <0.01 |
| | 2 | 441 | 3th | 0.19 | 1.85 | 14.63 | 0 | 85.37 | 0 | <0.01 | 0.99 | 0.17 | 0.04 | 0.16 | <0.01 |
| | 3 | 463 | 2nd | 0.27 | 1.27 | 0 | 43.39 | 56.61 | 0 | 0.03 | 1.0 | 0.67 | 0.02 | 0.07 | <0.01 |
| Pasture | 1 | 425 | 3th | 0.64 | 3.49 | 8.57 | 62.35 | 0 | 29.08 | 0.3 | 0.33 | 0.43 | 0.66 | 0.02 | 0.22 |
| | 2 | 461 | 3th | 0.13 | 2.00 | 0 | 97.69 | 0 | 2.31 | 0.21 | 0.01 | 0.45 | 0.05 | <0.01 | 0.14 |
| | 3 | 479 | 2nd | 0.17 | 4.80 | 16.41 | 65.35 | 0 | 18.24 | 0.02 | 0.38 | 0.15 | 0.02 | 0.02 | <0.01 |

**Table S2: Mean ± S.D. isotopic signatures of resources and consumers sampled in the three land use categories.** The letters *a* and *b* indicate which signatures are different according to *post hoc* test. The letter "n" indicates the number of replicates used in each group analysis.

| | δ13C | | | | | | | | | | δ15N | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Resources** | Natural cover | | n | Pasture | | n | Sugar cane | | n | p | Natural cover | | n | Pasture | | n | Sugar cane | | n | p |
| Algae | -29.96 ± 5.44 | | 10 | -32.76 ± 5.81 | | 10 | -30.10 ± 2.83 | | 5 | 0.45 | 6.21 ± 2.43 | | 10 | 6.32 ± 1.98 | | 10 | 4.52 ± 1.56 | | 5 | 0.27 |
| CPOM | -30.15 ± 0.55 | | 30 | -30.17 ± 0.46 | | 17 | -30.08 ± 0.61 | | 30 | 0.91 | 0.68 ± 0.56 | *b* | 30 | 2.19 ± 1.03 | b | 17 | 4.13 ± 2.46 | *a* | 30 | **<0.01** |
| Grasses | – – | | – | -16.83 ± 3.55 | | 15 | – – | | – | – | – – | | – | 4.90 ± 2.74 | | 15 | – – | | – | – |
| Periphyton | -27.16 ± 1.93 | | 15 | -25.86 ± 4.71 | | 15 | -25.84 ± 0.97 | | 15 | 0.39 | 4.60 ± 0.85 | *b* | 15 | 6.15 ± 0.77 | a | 15 | 6.71 ± 1.94 | *a* | 15 | **<0.01** |
| Sugarcane | – – | | – | – – | | – | -13.11 ± 0.25 | | 10 | – | – – | | – | – – | | – | 4.46 ± 0.75 | | 10 | – |
| FPOM | -27.18 ± 1.28 | *b* | *17* | -24.01 ± 2.98 | *a* | *18* | -24.88 ± 2.39 | *a* | *25* | **<0.01** | 3.38 ± 0.98 | *b* | *17* | 4.01 ± 1.07 | b | *18* | 6.31 ± 1.87 | *a* | *25* | **<0.01** |
| **Consumers** | | | | | | | | | | | | | | | | | | | | |
| Collector | -27.12 ± 0.93 | | 15 | -26.94 ± 4.58 | | 12 | -25.97 ± 1.57 | | 15 | 0.10 | 4.65 ± 1.20 | *b* | *15* | 6.15 ± 0.79 | a | 12 | 7.22 ± 2.05 | *a* | 15 | **<0.01** |
| Filter | -26.94 ± 1.32 | *a* | 15 | -28.64 ± 4.44 | *a* | 15 | -25.02 ± 0.90 | *b* | 15 | **<0.01** | 5.90 ± 1.01 | *b* | *15* | 7.37 ± 0.62 | a | 15 | 7.76 ± 1.60 | *a* | 15 | **<0.01** |
| Shrimp-shredder | -26.20 ± 1.89 | | 13 | -29.68 ± 4.44 | | 7 | – – | | – | 0.12 | 8.20 ± 0.94 | *b* | *13* | 9.64 ± 0.80 | a | 7 | – – | | – | **<0.01** |
| Insect-shredder | – – | | – | -21.14 ± 5.12 | | 6 | -27.10 ± 2.07 | | 3 | 0.10 | – – | | – | 5.64 ± 1.02 | b | 6 | 8.75 ± 1.44 | *a* | 3 | **<0.05** |
| Predator | -27.30 ± 1.52 | *b* | 15 | -28.08 ± 4.48 | *ab* | 15 | -24.93 ± 1.93 | *a* | 15 | **<0.01** | 6.61 ± 0.92 | *b* | *15* | 8.09 ± 0.60 | a | 15 | 9.40 ± 2.45 | *a* | 15 | **<0.01** |
| Scraper | -28.53 ± 1.58 | *b* | 15 | -27.25 ± 2.79 | *a* | 12 | -26.39 ± 0.87 | *a* | 14 | **<0.01** | 4.32 ± 1.03 | *c* | *15* | 5.45 ± 1.25 | b | 12 | 7.41 ± 2.22 | *a* | 14 | **<0.01** |

**Table S3. Stable isotope analysis (SIAR) results of the food source proportions in the diet of the functional trophic groups (FTG) (95% confidence interval).**

| Category | Resources | Consumers | | | | |
|---|---|---|---|---|---|---|
| | | Collectors | Filter-feeders | Shrimp-shredders | Insect-shredders | Scrapers |
| Natural Cover | Algae | 0.04 (0.00-0.10) | 0.09 (0.00-0.22) | 0.40 (0.14-0.60) | - | 0.08 (0.00-0.19) |
| | CPOM | 0.26 (0.11-0.43) | 0.13 (0.00-0.26) | 0.03 (0.00-0.09) | - | 0.57 (0.40-0.72) |
| | Periphyton | 0.21 (0.00-0.43) | 0.34 (0.02-0.61) | 0.43 (0.11-0.74) | - | 0.13 (0.00-0.31) |
| | FPOM | 0.49 (0.19-0.78) | 0.44 (0.11-0.81) | 0.14 (0.00-0.36) | - | 0.22 (0.00-0.44) |
| Pasture | Algae | 0.14 (0.00-0.29) | 0.29 (0.13-0.45) | 0.44 (0.16-0.76) | 0.09 (0.00-0.25) | 0.11 (0.00-0.27) |
| | CPOM | 0.38 (0.21-0.54) | 0.19 (0.05-0.32) | 0.10 (0.00-0.28) | 0.28 (0.02-0.49) | 0.49 (0.26-0.72) |
| | Grasses | 0.12 (0.00-0.26) | 0.07 (0.00-0.18) | 0.10 (0.00-0.26) | 0.27 (0.01-0.48) | 0.10 (0.00-0.22) |
| | Periphyton | 0.13 (0.00-0.30) | 0.29 (0.08-0.50) | 0.25 (0.00-0.48) | 0.12 (0.00-0.30) | 0.10 (0.00-0.27) |
| | FPOM | 0.23 (0.00-0.44) | 0.16 (0.00-0.34) | 0.11 (0.00-0.30) | 0.24 (0.00-0.45) | 0.20 (0.00-0.41) |
| Sugar cane | Algae | 0.26 (0.01-0.47) | 0.18 (0.00-0.33) | - | 0.23 (0.00-0.43) | 0.21 (0.01-0.37) |
| | CPOM | 0.24 (0.01-0.44) | 0.22 (0.02-0.39) | - | 0.22 (0.00-0.42) | 0.3 (0.09-0.50) |
| | Periphyton | 0.19 (0.00-0.38) | 0.24 (0.01-0.44) | - | 0.23 (0.00-0.44) | 0.23 (0.01-0.43) |
| | Sugarcane | 0.10 (0.02-0.19) | 0.15 (0.07-0.21) | - | 0.10 (0.00-0.27) | 0.07 (0.00-0.14) |
| | FPOM | 0.21 (0.00-0.41) | 0.21 (0.01-0.38) | - | 0.22 (0.00-0.42) | 0.19 (0.00-0.37) |

**Table S4: Stable isotope analysis in R (SIAR) results of the prey proportions in predator diets (95% confidence interval).**

| Resources | Category | | |
|---|---|---|---|
| | Natural Cover | Pasture | Sugar cane |
| Collectors | 0.33 (0.00-0.61) | 0.28 (0.01-0.54) | 0.28 (0.00-0.54) |
| Filter-feeders | 0.10 (0.00-0.29) | 0.11 (0.00-0.26) | 0.31 (0.01-0.57) |
| Shrimp-shredders | 0.04 (0.00-0.11) | 0.04 (0.00-0.10) | - |
| Insect-shredders | - | 0.17 (0.00-0.37) | 0.17 (0.00-0.38) |
| Scrapers | 0.53 (0.24-0.85) | 0.40 (0.17-0.64) | 0.24 (0.00-0.48) |

# Chapter II

# Landscape variables influence taxonomic and trait composition of insect assemblages in neotropical savanna streams

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# Landscape variables influence taxonomic and trait composition of insect assemblages in neotropical savanna streams

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## Abstract

1. Stream invertebrate assemblages are structured by environmental factors acting at multiple spatial scales. Identifying the spatial scale that most influences the species-environment relationships is a major goal of community ecology.
2. We evaluated the importance of catchment and site scales and associated environmental variables in shaping Ephemeroptera, Plecoptera and Trichoptera (EPT) assemblages in neotropical savanna headwater streams.
3. Sampling sites were associated with 20 catchment-scale variables that depicted land cover and land use as well as natural geophysical variables such as altitude and climate. Site-scale habitat was characterized by 55 variables that described habitat hydromorphology, substrate, flow, canopy, in-stream cover, and water quality. EPT traits were assessed using 28 categories of 7 biological traits, which represented the best available current knowledge for EPT in neotropical savanna streams.
4. We analyzed the relationships between the catchment- and site-scale habitat variables and the taxonomic and trait composition of insect assemblages using 1760 samples collected in 160 stream sites.
5. Catchment- and site-scale variables both explained significant variation of EPT taxon and trait composition. Substrate, habitat hydromorphology, and land use most influenced variation in taxonomic composition whereas trait composition was mainly affected by land use. Catchment geographic position explained less assemblage variation.

6. To our knowledge, our study is the first assessment of the impact of catchment- and site-scale variables on the trait and taxon composition of stream insect assemblages in neotropical savanna streams. It highlights the need for better regional biological knowledge of invertebrates in order to generate more general trait-based approaches in freshwater ecosystem conservation.

**Key-words**: spatial scale, physical and chemical habitat, aquatic insects, EPT, land use

**Introduction**

Streams are organized hierarchically in the landscape, within which environmental factors operate at a range of spatial scales (Frissell et al., 1986; Mykrä, Heino & Muotka, 2007; Leps et al., 2015), directly or indirectly affecting the structure and composition of biological assemblages (Townsend et al., 2003; Sandin & Johnson, 2004; Macedo et al., 2014). Therefore, assessing spatial patterns is essential for a comprehensive understanding of the drivers that determine the structural and functional diversity of stream assemblages (Heino, Muotka & Paavola, 2003; Sandin & Johnson, 2004; Hoeinghaus, Winemiller & Birnbaum, 2007; Macedo et al., 2014; Liu et al., 2016).

Site-scale physical and chemical habitat is determined by larger-scale processes (Leal et al., 2016), which hinders disentangling the roles of different environmental drivers in aquatic communities (Frissell et al., 1986; Allan, 2004). For example, catchment characteristics affect riparian zones, substrates and hydrological regimes, which in turn affect habitat availability and thereby influence the structure and composition of aquatic assemblages (Vannote et al., 1980; Allan, 2004; Greenwood & Booker, 2016). Furthermore, geographical position may influence environmental factors that determine spatial patterns in assemblage structure and composition (Townsend et al., 2003).

Understanding the role of catchment- and site-scale environmental variables in determining stream invertebrate biodiversity is especially relevant in tropical freshwater ecosystems (e.g., Al-Shami et al., 2013; Tonkin, Arimoro & Haase, 2016). Although these systems are among the most diverse on earth, they are highly threatened by a broad suite of stressors (Dudgeon et al., 2006; Strayer & Dudgeon, 2010; Taniwaki et al., 2016). The effects of human activities on tropical streams are poorly understood and the pace of stream deterioration exceeds the pace of scientific research to understand ecosystem responses (Ramírez, Pringle & Wantzen, 2008). For example, the neotropical savanna (Cerrado) is the second largest biome in South America, a biodiversity hotspot (Myers et al., 2000), and one of the most threatened biomes in the world. However, little attention has been paid to the conservation of its freshwater ecosystems and biota (Klink & Machado, 2005; Strassburg et al., 2017). Habitat fragmentation and agriculture are the main threats to biodiversity conservation in this region (Carvalho, De Marco & Ferreira, 2009; Overbeck et al., 2015; Hunke et al., 2015). Although studied worldwide (e.g., Townsend et al., 2003; Beauchard, Gagneur & Brosse, 2003; Heino et al., 2007; Bonada, Dolédec & Statzner, 2012; Al-Shami et al., 2013), spatial patterns of aquatic assemblages are poorly considered in tropical savanna streams (Macedo et al., 2014).

In the neotropics, there have been a few studies addressing the influence of environmental drivers at different scales on functional composition of phytoplankton (e.g., Machado et al., 2016) and fishes (e.g., Terra, Hughes & Araújo, 2016; Leitão et al., 2017), but not invertebrates. Understanding how environmental pressures interact to affect functional composition of aquatic invertebrates at different scales and in different regions is therefore a major challenge for freshwater management in tropical regions and globally.

Most previous studies addressing species traits have been generally restricted to trophic guilds (e.g. Brasil et al., 2014; Castro et al., 2016; Ferreira et al., 2017). However, the Multiple-Trait Based (MTB) approach (Dolédec & Statzner, 2010; Menezes, Baird & Soares, 2010) offers more mechanistic understanding than traditional taxonomy-based approaches for assessing relationships between stream assemblage composition and environmental variables. This is because multiple traits reflect multiple functional relationships between biota and environmental characteristics (Townsend, Dolédec & Scarsbrook, 1997; Feld & Hering, 2007; Dolédec, Phillips & Townsend, 2011). For example, Townsend, Dolédec & Scarsbrook (1997) found that disturbance strengthened the pattern of preponderance of resilience/resistance traits in benthic insect communities. Feld & Hering (2007) observed that, in contrast to taxonomic structure, functional measures were more strongly related to hydromorphological gradients at various spatial scales. Dolédec, Phillips & Townsend (1997), assessing aquatic invertebrate trait and taxonomic response to land-use, found that trait responses were consistent at the broad and catchment scales, with similar traits responding to land-use at both scales. Functional trait information for neotropical aquatic invertebrates has increased (Tomanova & Usseglio-Polatera, 2007; Tomanova, Moya & Oberdorff, 2008; Reynaga & Santos, 2013; Dedieu et al., 2015; Milesi, Dolédec & Melo, 2016) and provides opportunity for MTB analyses to be used in determining their interactions with multi-scale pressures. Nonetheless, this approach has not been attempted previously in the neotropical savanna.

Ephemeroptera, Plecoptera and Trichoptera (EPT) comprise diverse aquatic assemblages in headwater streams (Vinson & Hawkins, 1998; Bispo et al., 2006), and they have important roles in nutrient cycling and energy transfer (Graça, 2001; Ferreira et al., 2014). In addition, the EPT are commonly used for assessing the biological condition of stream ecosystems in North America (e.g., Lenat, 1988; Stoddard et al., 2008), South America (e.g., Pereira et al., 2016; Chen et al., 2017), Europe (e.g., Hering et al., 2006), Asia (e.g., Chen et al., 2014), and Australia (e.g., Chessman et al., 2006). In this study, we investigated the response of taxonomic and trait composition of EPT assemblages to several physical and chemical variables at catchment and site scales and geographic position in neotropical savanna headwater streams. We sought to answer three questions: (i) Which of those two scales most accounts for the relationships between landscape variables and EPT assemblages in terms of taxonomy and traits? (ii) Are these relationships the same for both natural and human-modified environmental variables? (iii) To what degree does geographic position (longitude/latitude) explain EPT assemblage distribution?

## Methods

### *Study area*

The study area was located in the neotropical savanna of south-eastern Brazil (the Cerrado), which has two well-defined seasons: a wet season from October to April (rainfall 100-330 mm/mo), and a dry season from May to September (rainfall 10-55 mm/mo), with 1600 mm mean annual rainfall (Ferreira et al., 2017). We sampled wadeable 1st-3rd order streams (average width = 3.4 ± 1.9 m, average depth = 0.25 ± 0.12 m) belonging to four different hydrological units (HU): São Francisco, Rio Grande, Paranaíba, and Araguari (Fig. 1). In each HU, we sampled a drainage area within 35 km upstream of each hydropower dam: Três Marias, Volta Grande, São Simão, and Nova Ponte, respectively in each of these HUs. We collected samples in a given HU in a given year over the period between 2010 and 2013 at the end of the dry season (September).

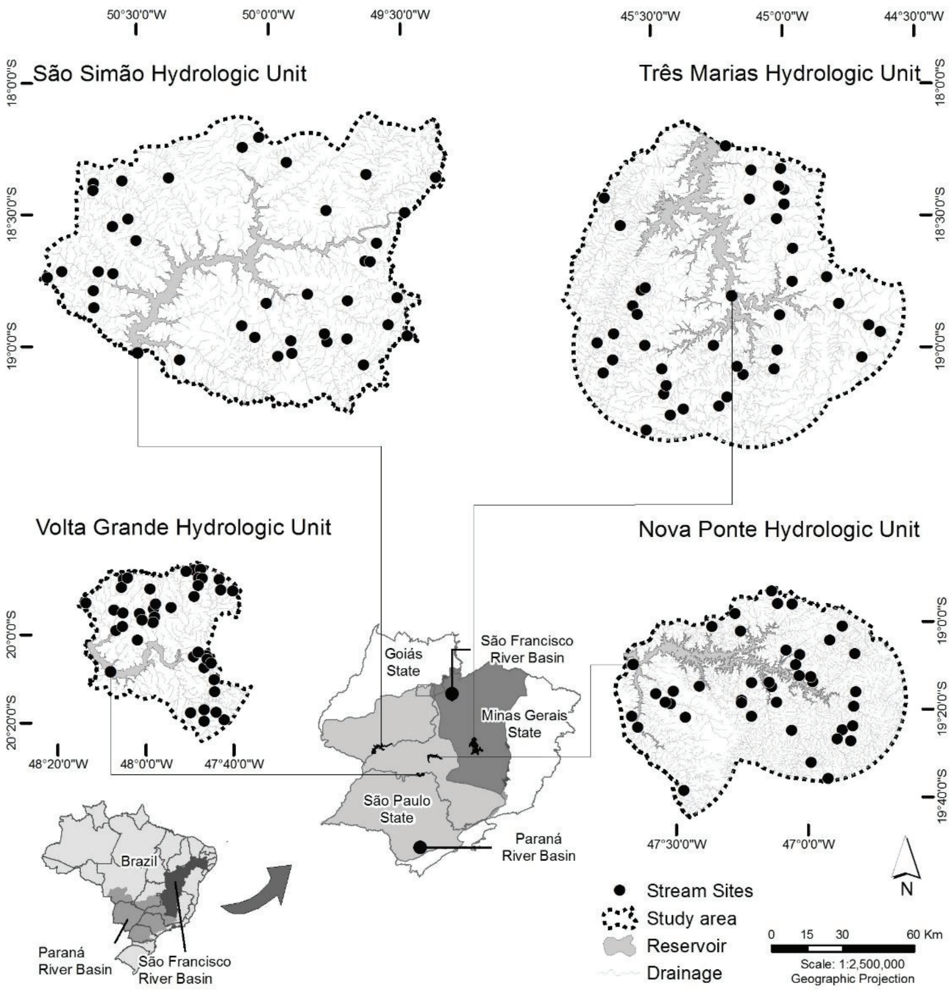


**Figure 1**. Locations of wadeable stream sites (n=160) in four hydrological units in the neotropical savanna.

*Site selection*

In each HU, we randomly selected 40 perennial stream sites, totaling 160 sites for the 4 HUs. Site selection followed the generalized random tessellation stratified sampling design developed for the U.S. EPA's national Wadeable Stream Assessment (Stevens & Olsen, 2004; Olsen & Peck, 2008). In this approach, a master sample frame is first established using a digital hydrographical map (1:100,000 scale) and then the sample sites are selected via a hierarchical, spatially weighted criterion (Stevens & Olsen, 2004). This procedure ensures a balanced selection of sites across the range of stream orders and geographic location, besides enabling the selection of sites along different disturbance levels (Macedo et al., 2014).

*Environmental variables*

Environmental variables acting at varying spatial scales within HUs were classified into three groups: catchment-scale, site-scale, and geographic position (Fig. 2, Table S1). A total of ~250 catchment- and site-scale variables were initially measured. We eliminated those variables that had more than 90% zero values, low variability, and high correlation with each other (r > |0.8|). For those variables that correlated with each other, we retained the most ecologically meaningful ones. Because we initially produced many environmental variables (~250), we defined criteria to select the most important variables, based on the literature. Those steps yielded a final set of 75 variables (Macedo et al., 2014).

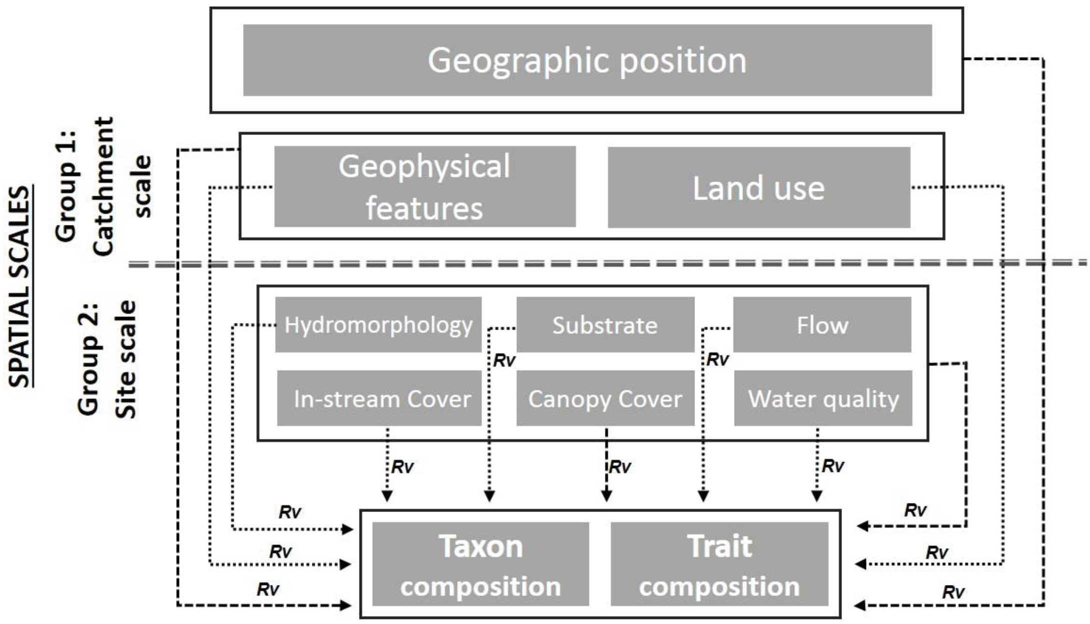


**Figure 2:** Hierarchical organization used in this study to quantify the relationship between geographic position, environmental variables, and the taxonomic and trait composition of EPT assemblages. Environmental variables (see Table S1) were classified into catchment-scale variables, which comprise geophysical features and land use, and site-scale variables, which depicted habitat hydromorphology, substrate, flow, in-stream cover, riparian canopy cover, and water quality. *Rv*-coefficients were computed for each set of environmental variables to assess

their respective contribution to the variability of the aquatic invertebrate taxonomic or trait composition.

Catchment-scale variables included land use and land cover variables as well as natural geophysical variables: rainfall, altitude, drainage area, elevation and slope (range, average and standard deviation). Catchment total annual rainfall time series were obtained from the Brazilian National Water Agency (ANA, 2014). Using GIS software, we extracted geophysical variables from 160 catchments, which were manually delineated to the entire catchment area (km²) for each site. Basin elevation data (range, mean and standard deviation) was extracted from Shuttle Radar Topographic Mission - SRTM imagery (USGS 2005) and catchment slope was calculated from the maximum rate of change in elevation in every grid cell, based on SRTM elevation raster.

We assessed catchment land use and land cover for each site by interpreting high-resolution satellite images (0.6-5 m spatial resolution, Google Earth data; Google 2014) in conjunction with Landsat multispectral satellite images (R4G3B2 false color band combination). The high-resolution images provided information about the shape and texture of the elements, and the multispectral images allowed distinguishing vegetation leaf structure. We identified four natural savanna cover types (woodland savanna, grassy-woody savanna, parkland savanna, and wetland palm swamp) (IBGE, 2012) and four human-induced land uses (pasture, agriculture, eucalyptus forest, and urban areas) in the 160 catchments. We also calculated the total percentage of natural land cover by summing the preceding four natural land covers. Additionally, to further characterize potential anthropogenic influences on the sites, we measured Euclidian distance to cities and to paved highways (km) and we calculated the density of households (houses/km²) in each catchment.

Physical habitat at the site scale was characterized using the U.S. EPA field methods (Peck et al., 2006; Hughes & Peck, 2008) adapted to neotropical savanna headwater streams by Callisto et al. (2014). The length of each sampled site was 40 times its mean wetted width, with a minimum length of 150 m. Each reach was divided into 11 equally spaced transects. At each site, we characterized the physical habitat by 10 channel hydromorphological variables (e.g., thalweg depth, bank angle, channel sinuosity; see Table S1), 12 substrate variables (e.g.,

% of boulders, % of sand, % of total organic matter, % of large wood); 6 flow variables (e.g., velocity, % of glides, % of pools), 11 riparian canopy cover variables (e.g., herbaceous cover, exposed soil, ground cover) and 8 in-stream habitat variables (e.g., aquatic macrophytes, large woody debris). All site variables were calculated according to Kaufmann et al. (1999), who described concepts and analytical procedures for calculating metrics based on data generated from the physical habitat field protocols. We also measured temperature, electrical conductivity, pH, turbidity, and total dissolved solids (TDS) in situ using a multi-parameter probe (YSI, 650 MDS, model 6920). In the laboratory, we determined total alkalinity, total nitrogen, and dissolved oxygen concentrations from preserved water following Standard Methods (APHA, 2005). Water samples and parameters were always obtained at each site at the same time of day (around 10 AM).

*Benthic macroinvertebrate sampling*

We sampled benthic macroinvertebrates at all 160 sites with a D-frame kick net (30 cm aperture, 500 µm mesh). Eleven sub-sample units (0.09 m² quadrat) were taken per site, one per transect (see above), generating one composite sample for each site and totaling an area of ~1 m² per site. Thus, stream sites were our replicates. The sample units were obtained by following a systematic zigzag trajectory along the reach to avoid bias in habitat selection (Peck et al., 2006; Hughes & Peck, 2008). Immediately after collection, samples were placed in individual plastic buckets and preserved with 4% formalin. In the laboratory, macroinvertebrates were sorted, and EPT individuals were identified to genus by means of taxonomic keys (Pes, Hamada & Nessimian, 2005; Dominguez et al., 2006; Mugnai, Nessimian & Baptista, 2010) and counted under a 80x magnification stereomicroscope.

*Biological traits*

We used trait information that was available exclusively for neotropical macroinvertebrates (Baptista et al., 2006; Tomanova & Usseglio-Polatera, 2007; Reynaga & Santos, 2012; Dedieu et al., 2015). Biological trait categories described EPT genus profiles in terms of resilience or resistance ability (including morphology and life cycle) and feeding habits. Feeding habits and body size potentially reflect stream functional aspects (e.g., nutrient cycling, biomass accumulation), and other morphological and behavioral traits were potentially linked to physical habitat constraints (Tomanova & Usseglio-Polatera, 2007). We produced a trait database comprising 7 biological traits and 28 trait categories (Table 1). The affinity of each taxon for each category within a trait was described using a fuzzy coding approach (Chevenet, Dolédec & Chessel, 1994). The score for each taxon belonging to each trait category ranged from 0 to 3, with 0 indicating no affinity with the category, 1 indicating weak affinity, 2 indicating moderately strong affinity, and 3 indicating strong affinity. This coding methodology helps to compensate for different types and levels of information available, and the inclusion of within-species trait variation associated to the natural variation of populations (Chevenet et al., 1994; Menezes et al., 2010). To determine the body size of each EPT genus, we measured the body lengths (from head to the end of the abdomen) of ~10% of all EPT organisms sampled in the 160 sites. These measurements were then classified into 6 categories according to the distribution of sizes in a histogram, where the breaks were defined so that the categories had a normal distribution (Table 1).

Affinity scores were standardized so that their sum for a given taxon and a given trait equaled 1. As recommended by Gayraud et al. (2003), we described the trait composition of assemblages by multiplying the frequency of each category per trait by the ln-transformed abundances of taxa in a site. The resulting trait-by-sites table, which contained the abundance of each category per trait in each site, was further analyzed.

**Table 1.** Traits and their categories and codes used for 73 EPT genera collected in neotropical savanna streams.

| Traits | Code | Categories |
|---|---|---|
| Body Size | SIZE_<1.5 | <1.5 |
| | SIZE_1.5_2.5 | 1.5 - 2.5 |
| | SIZE_2.5_3.5 | 2.5 - 3.5 |
| | SIZE_3.5_5 | 3.5 - 5.0 |
| | SIZE_5_10 | 5.0 - 10.0 |
| | SIZE_large | >10 |
| Potential number of cycles per year | CY_<1y | < or = 1 |
| | CY_>1y | > 1 |
| Feeding Habits | FG_collector | Collector-Gatherer |
| | FG_shredder | Shredder |
| | FG_scraper | Scraper |
| | FG_filterer | Collector-Filterer |
| | FG_predator | Predator |
| Locomotion | LO_burrower | Burrow |
| | LO_climber | Climber |
| | LO_sprawler | Sprawl |
| | LO_clinger | Clinger |
| | LO_swimmer | Swimmer |
| Body flexibility | FL_low | <10 |
| | FL_inter | >10-45 |
| | FL_high | >45 |
| Body form | FO_streamlined | Streamlined |
| | FO_flattened | Flattened |
| | FO_cylindrical | Cylindrical |
| | FO_spherical | Spherical |
| Relation to substrate | RS_free | Free Living |
| | RS_silknet | Silk net builders |
| | RS_case | Case builder |

*Data analysis*

To obtain scores for sites based on taxon composition, we performed principal components analysis (PCA) on the ln(x+1)-transformed abundance of taxa, and to obtain scores for sites based on trait composition, we used a fuzzy principal components analysis (FPCA) on the table that contained the ln(x+1)-transformed trait-category abundances in each site

(Chevenet et al. 1994). To test for homogeneity among HUs, which would allow using all 160 sites together, we compared the observed variance across the sites in each HU and the distribution of simulated variances obtained after 999 permutations of the rows (sites) of the taxon (or trait) composition table. For taxon and trait composition, the tests indicated a very weak separation of sites grouped by HU (explained variance=0.094 and 0.078, simulated-p =0.001, for taxa and traits respectively). We thus considered the totality of sites in further analyses.

Continuous environmental variables were log-transformed and proportional variables were arcsine-squared root transformed to meet normality of distributions. To identify and produce smaller sets of the most representative variables, we performed PCA on catchment- and site-scale variables as a whole, and for separate sets (i.e. geophysical features, land use, habitat hydromorphology, substrate, flow, riparian canopy cover, in-stream cover, water physical and chemical, Table S1). We further investigated the relationships between geographical locations and the above environmental variables and taxon (or trait) composition of EPT assemblages by using co-inertia analyses (Dolédec & Chessel, 1994; Dray, Chessel & Thioulouse, 2003). This analysis is an eigenvector technique that matches two data sets (in this case, environmental variables and invertebrate data) in a symmetric way. The correlation between each set of environmental variables and EPT taxon or trait composition was measured with the *Rv*-coefficient (Fig. 2), which is a multidimensional equivalent of the ordinary correlation coefficient between two variables (Robert & Escoufier, 1976). We performed Monte-Carlo tests to evaluate the statistical significance of *Rv*-coefficients by comparing the observed *Rv*-coefficient to the distribution of 999 replicated matches of the two tables (after the random permutations of their rows, i.e., sites). In addition, to assess the importance of the site and catchment scales in comparison to geographical position in determining EPT taxon (or trait) composition, we used a procedure proposed in Townsend et al. (2003). In this approach, we let *E1* and *E2* denote the two environment tables at the site- and/or the catchment-scales, and considered F the EPT taxon (or trait) composition table. We tested the null hypothesis $Rv(E1,F) = Rv(E2,F)$ against the alternative $Rv(E1,F) > Rv(E2,F)$ and we performed bootstraps on the statistics $t = Rv(E1,F) - Rv(E2,F)$ using 999 replicates. We assessed the statistical significance of the observed RV-coefficient difference by comparing it to the distribution of the simulated values. Percent changes between Rv-coefficients were obtained by *[(Rv(E1,F) - Rv(E2,F)) / (Rv(E1,F)) x 100]*.

Finally, given that the variability within a table is related to the number of variables, which differed between taxonomic and trait composition (73 genera vs. 28 trait categories), we simulated taxonomic-composition tables by randomly selecting 28 genera (i.e. the same number as trait categories) and recalculated the *RV*-coefficient for each set of environments with this reduced taxon composition. The distribution of 999 simulated variances was then compared with the observed variance obtained from the analysis of the entire taxonomic and trait composition tables (see e.g. Bonada et al. 2007). All analyses were conducted in R (R Core Development Team, 2015) with the ade4 package (Chessel, Dufour & Thioulouse, 2004).

## Results

### *Taxonomy*

We collected 53,698 EPT individuals distributed in 20 families and 73 genera. Four sites had no EPT and were excluded from further analysis (hereafter n=156 sites). Co-inertia analysis showed a significant relationship between EPT taxon composition and catchment-scale variables (Rv = 0.247, P = 0.001; Table 2). The first two axes incorporated 95.5% of the environmental variability and 55% of the EPT variability (Table 2). The most significant variables along the first co-inertia axis included the percentage of parkland and natural cover as opposed to percentage of agricultural lands (Fig. 3a). Along the second axis, prominent variables included altitude, catchment elevation range, and rainfall as opposed to percentage of palm swamp, drainage area, and elevation standard deviation (Fig. 3b). EPT taxonomic richness was significantly related to the first co-inertia axis (R2 = 0.068, P < 0.001). Taxa most responding to the environmental patterns described by the first co-inertia axis included Ephemeroptera, such as Callibaetis, Cloeodes, Caenis, and Traverhyphes (Fig. 3c). Taxa less sensitive to land use included Trichoptera (*Smicridea*) and Ephemeroptera (*Leptohyphes* and *Zelusia*). Along the second co-inertia axis, taxa colonizing higher elevation streams included Plecoptera (*Tupiperla*) and Ephemeroptera (*Tricorythopsis*). In contrast, lower elevation streams supported Ephemeroptera such as *Hydrosmilodon* and *Farrodes* and Trichoptera such as *Helicopsyche* (Fig. 3c).

**Table 2:** Results of co-inertia analyses performed between geographic position, catchment- and site-scale variables and (a) taxonomic and (b) trait composition of EPT assemblages. *Rv*: correlation coefficient between tables, *P*: simulated probability equal to the frequency of random values higher than the observed *Rv*-coefficient, %: percentage of variance in EPT taxonomic (a) or trait (b) composition explained by the first-two axes of a co-inertia analysis.

| | *Rv* | *P* | % |
|---|---|---|---|
| (a) | | | |
| Geographic position | 0.140 | 0.001 | 43.7 |
| Catchment | 0.247 | 0.001 | 55.1 |
| Site | 0.320 | 0.001 | 84.9 |
| (b) | | | |
| Geographic position | 0.067 | 0.001 | 69.1 |
| Catchment | 0.133 | 0.001 | 80.7 |
| Site | 0.118 | 0.001 | 92.7 |

At the site scale, the relation between EPT taxon composition and environmental variables was slightly stronger than for catchment-scale variables ($Rv$ = 0.320, $P$ = 0.001; Table 2). The first two co-inertia axes represented up to 85.9% of the environmental variability and 84.9% of the EPT variability (Table 2). The most important site-scale variables along the first co-inertia axis included mean bankfull and wetted width, substrate diameter, and mean width/depth ratio as opposed to embeddedness, percentage of fines, percentage of areal cover in live trees, and turbidity (Fig. 3d). The most significant variables along the second co-inertia axis included mean water velocity, and percentage of pools, rapids and glides (Fig. 3e). The first co-inertia axis separated sites with high EPT diversity from those having lower diversity ($R^2$ = 0.268, $P$ < 0.001) with *Traverhyphes*, *Thraulodes*, *Cloeodes* as opposed to *Waltzoyphius*. Taxa most related to slow waters were the Ephemeroptera *Callibaetis*, *Caenis* and *Cloeodes*, as opposed to *Tricorythopsis*, *Tupiperla*, *Smicridea* and *Itaura* at higher flow velocities (Fig. 3f).

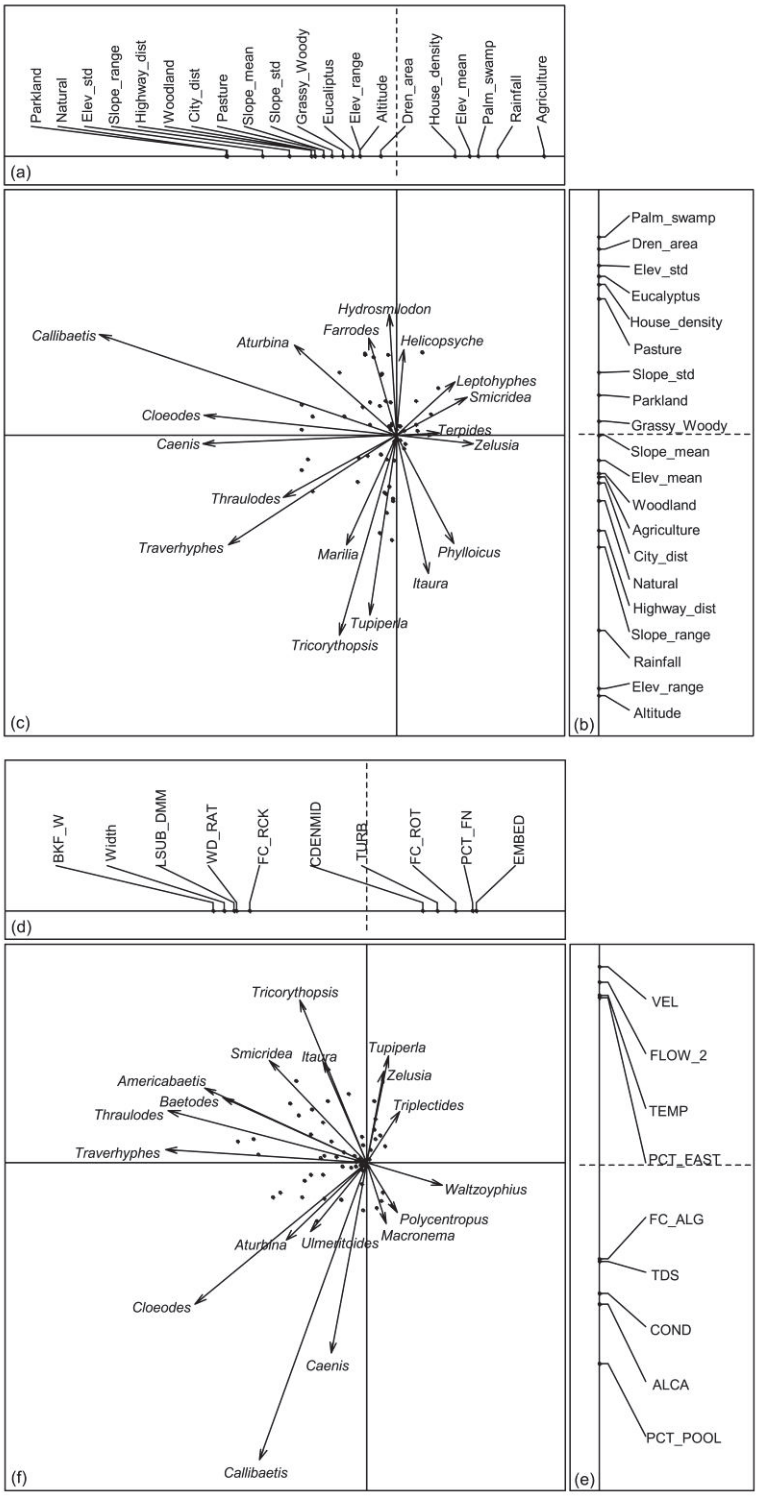


**Figure 3**: First two axes of a co-inertia analysis depicting the relationship between the *taxonomic* composition of EPT assemblages and (a-c) catchment-scale variables and (d-f) site-scale variables. (a) and (b) show the prominent catchment-scale variables along the first and second co-inertia axis respectively. (d) and (e) show the prominent site-scale variables along the first and second co-inertia axis respectively. (c) and (f) show the taxa loadings associated with the response of taxa to catchment-scale and site-scale variables respectively. Dots represent taxa with low loadings whose names are not shown for clarity (see Table S1 for variable acronyms).

The patterns observed above were significantly related (*Rv* = 0.140, $P < 0.001$; Table 2) to geographic position: an East-West gradient along the first co-inertia axis and a North-South gradient along the second co-inertia axis. However, the extracted variance was substantially lower than that obtained from catchment- and site-scale variables (Table 2).

*Biological traits*

Co-inertia analysis showed a significant relationship between EPT trait composition and catchment-scale variables (*Rv* = 0.133, $P = 0.001$). The first-two axes accounted for 90.3% of environmental variability and 80.7% of the trait variability (Table 2). Like EPT taxon composition, environmental variables were not equally important in accounting for trait composition. Along the first co-inertia axis, the percentage of natural cover, highway distance, and percentage of woodland and parkland were opposed to house density, percentage of agriculture, and palm-swamp (Fig. 4a). The most important variables along the second co-inertia axis included rainfall, elevation range, altitude, and percentage of agriculture as opposed to percentage of palm-swamp, percentage of eucalyptus, and standard deviation of elevation (Fig. 4b). The fauna responding to this gradient along the first co-inertia axis were free-living univoltine organisms with streamlined body form and/or intermediate body flexibility as opposed to silk net-builder organisms, having cylindrical body form and/or being multi-voltine. Along the second co-inertia axis, sprawlers, shredders, case-builders, and organisms with low body flexibility (<10º) and/or cylindrical body forms were opposed to scrapers and organisms with high body flexibility (>45º) (Fig. 4c).

The correlation between the trait composition of EPT assemblages and site-scale variables was slightly weaker than at the catchment scale (*Rv* = 0.118, $P = 0.001$). The first two axes accounted for 62.8% of the environmental variability and 92.7% of the trait variability (Table 2). The most important site-scale variables along the first co-inertia axis included relative bed stability, percentage of coarse gravel, mean substrate diameter, and percentage of fine gravel as opposed to water turbidity, percentage of fines, conductivity, embeddedness, and total dissolved solids (Fig. 4d). Along the second co-inertia axis, the most important variables were mean water velocity, discharge, temperature, and percentage of riffles opposed to percentage of pools, mean exposed soil, mean riparian canopy cover, mean thalweg depth, and reach length (Fig. 4e). Along this first co-inertia axis, sprawlers and univoltine organisms, with low body flexibility (<10º) and/or small body size were opposed to swimmers and multi-voltine organisms with high body flexibility (>45º). Along the second co-inertia axis, silk-net builders and organisms with cylindrical body form were opposed to scrapers and free-living organisms with streamlined body shape and intermediate body flexibility (Fig. 4f).

Like taxonomic composition, the patterns observed above were significantly related ($Rv$ = 0.067, $P$ < 0.001; Table 2) to geographic position: an East-West gradient along the first co-inertia axis and a North-South gradient along the second co-inertia axis (not shown). However the extracted variance was markedly lower than that obtained from catchment- and site-scale variables (Table 2).

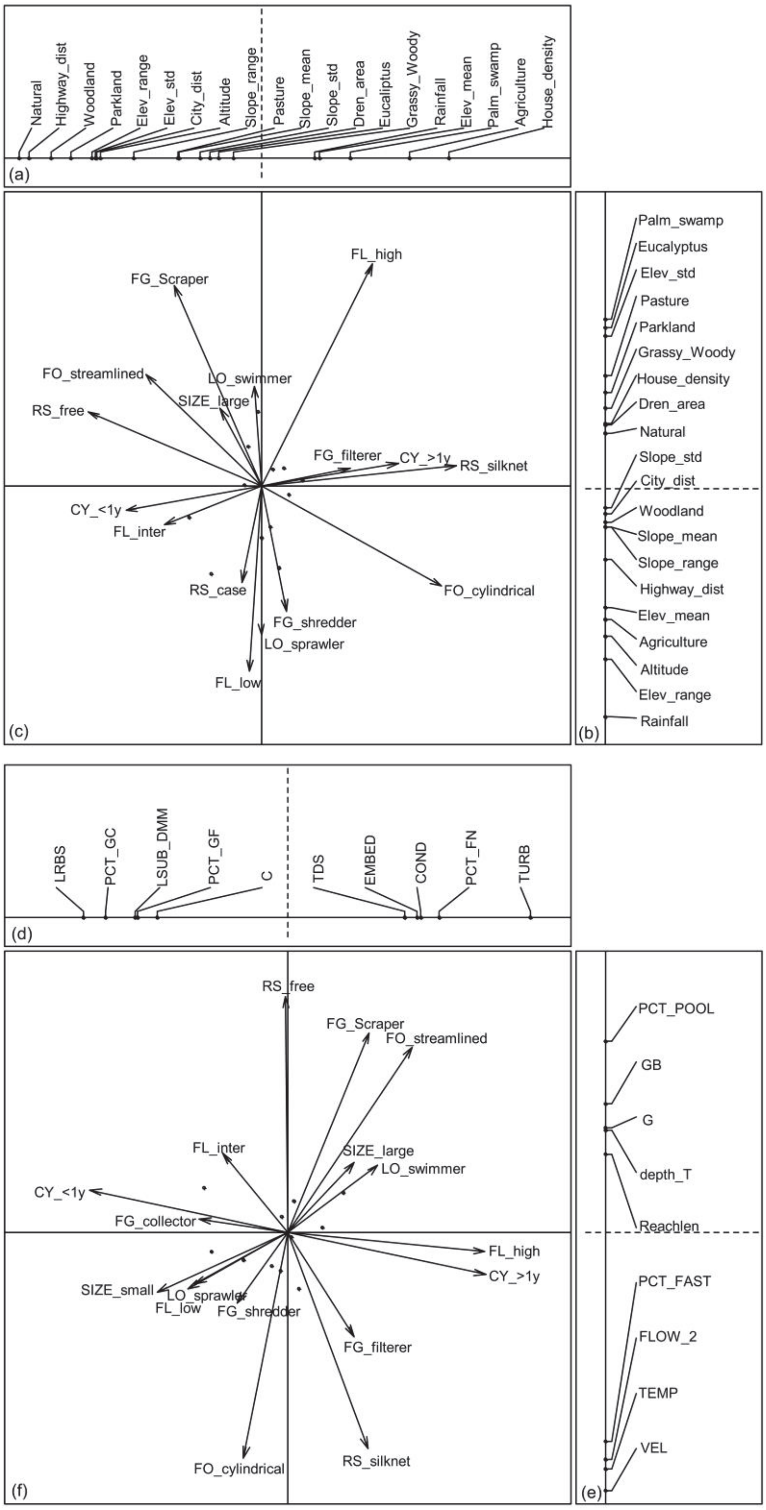


**Figure 4**: First two axes of a co-inertia analysis depicting the relationships between the *trait* composition of EPT assemblages and (a-c) catchment-scale variables and (d-f) site-scale variables. (a) and (b) show the prominent catchment-scale variables along the first and second co-inertia axis respectively. (d) and (e) show the prominent site-scale variables along the first and second co-inertia axis respectively. (c) and (f) show the taxa loadings associated to the variation in trait composition in response to catchment-scale and site-scale variables respectively. Dots represent taxa with low loadings whose names are not shown for clarity (see Table S1 for variable acronyms).

*Catchment- vs site-scale: taxa and traits*

Different environmental variables most influenced different taxa and trait variables. The taxa that were most influenced by catchment-scale variables, those most correlated with the first co-inertia axis, were *Aturbina*, *Tricorythopsis, Smicridea, Callibaetis*, whereas taxa most influenced by site-scale variables were *Traverhyphes, Itaura and Cloeodes* (Fig. 5a). Traits most influenced by catchment-scale variables were shredders and organisms with cylindrical or streamlined body form, and small body size, whereas traits most influenced by site-scale variables were silk-net builders, filterers, and organisms with more than one reproductive cycle per year and large body size (Fig. 5b).

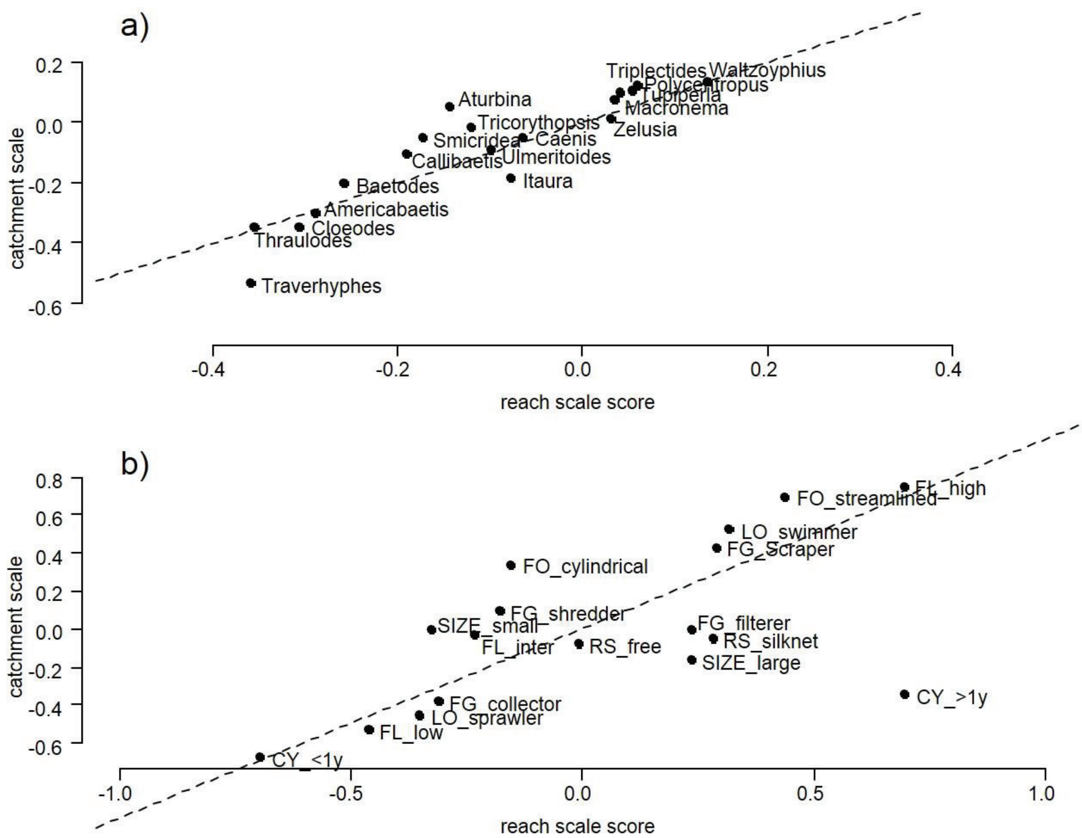


**Figure 5:** Influence of catchment and site scales on both a) taxa and b) traits most correlated with the first co-inertia axis. Each axis has the same variance. Taxa or traits above the dotted line are more influenced by catchment-scale variables and those below the line are more related to site-scale variables.

*Subsets of variables: taxa* vs. *traits*

We performed co-inertia analyses between each subset of environmental variables and taxon (or trait) composition. Substrate, hydromorphology, and land use were most correlated with EPT taxon composition (Fig. 6a, Table S2), whereas land use, flow, and water quality were most correlated with EPT trait composition (Fig. 6b, Table S2). Overall, the taxonomic structure of EPT assemblages exhibited stronger relationships with all groups of environmental variables than the functional trait composition (*Rv* = 0.181 ± 0.05 and *Rv*= 0.076 ± 0.03 for taxonomic and trait composition, respectively). Simulating the variance explained by each group of environmental variables for taxon composition by randomly selecting 28 genera (corresponding to the number of trait categories) confirmed that the higher variability in taxonomic data was not responsible for the difference in overall *Rv*-coefficients observed for taxon in comparison to trait composition (Fig. S1).

**Table 3:** Results from the bootstraps performed on the differences between *Rv*-coefficients resulting from the comparison between EPT *taxonomic* composition and geographic position, and catchment- and site-scale variables. P: probability that the observed difference $[Rv(E_1,F) - Rv(E_2,F)]$ is significantly positive. (n.s. = non significant).

| | Observed | *P* |
|---|---|---|
| Site – Geographic position | 0.180 | 0.001 |
| Catchment – Geographic position | 0.107 | 0.001 |
| Site – Catchment | 0.073 | n.s. |
| Land use – Canopy cover | 0.144 | 0.001 |
| Geophysical features – Canopy cover | 0.117 | 0.001 |
| Geophysical features – In-stream cover | 0.044 | 0.002 |
| Land use – Water Quality | 0.043 | 0.003 |
| Land use – In-stream cover | 0.070 | 0.001 |
| Land use – Flow | 0.040 | 0.012 |
| Geophysical features – Water Quality | 0.016 | 0.026 |
| Geophysical features – Land use | 0.027 | n.s. |
| Geophysical features – Flow | 0.013 | n.s. |
| Land Use – Hydromorphology | 0.010 | n.s. |
| Geophysical features – Hydromorphology | -0.017 | n.s. |
| Land Use – Substrate | -0.017 | n.s. |
| Geophysical features – Substrate | -0.043 | n.s. |

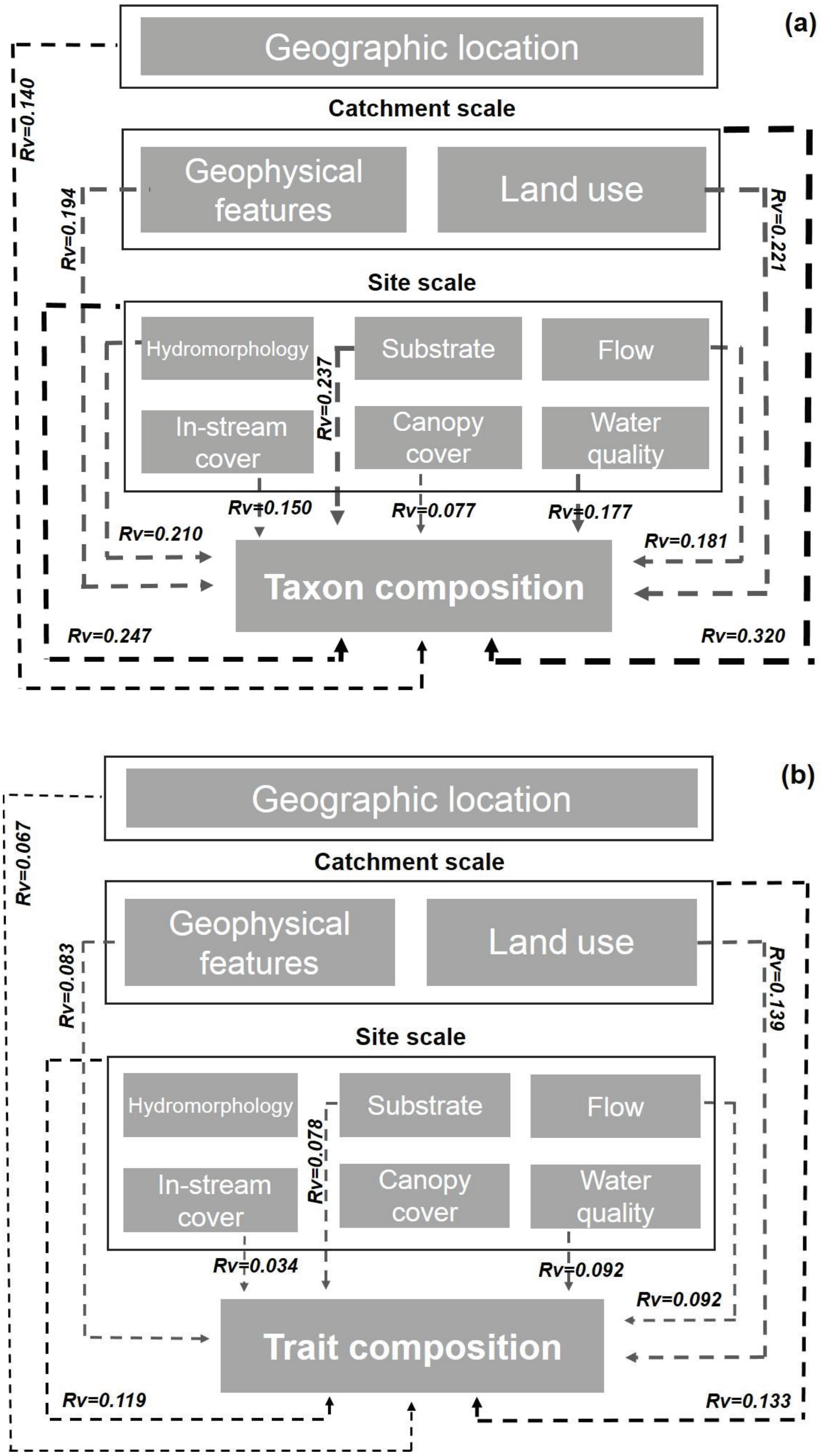


**Figure 6:** Relationships between the environmental variables and (a) taxon and (b) trait composition of EPT assemblages. Arrow width is proportional to the *Rv*-coefficient. Arrows not shown means that the correlation is not significant.

*Comparative importance of geographic position and catchment- and site-scale variables*

Considering EPT taxonomic composition, the differences in Rv-coefficients between the catchment- and site-scale variables as a whole were not significantly different from zero, suggesting that both groups equally influenced EPT taxon composition (Table 3). In this analysis, geographic position was less influential than catchment- and site-scale variables. Significant positive Rv-coefficient differences occurred between the geophysical features and site-scale variables describing riparian canopy cover (60.3% higher), in-stream cover (22.6%), and water quality (8.2%) (Table 3). In addition, significant positive Rv-coefficients differences occurred between land use and site-scale variables describing riparian canopy cover (65.1%), in-stream habitat cover (31.6%), water quality (19.4%), and flow (18.1%), suggesting that land use had a greater influence on taxon composition than site-scale variables (Table 3).

Considering the trait composition of EPT assemblages, the significant positive differences in *Rv*-coefficients between catchment and site-scale variables as a whole indicated that catchment-scale variables were slightly more influential than site-scale variables (11.2% higher; Table 4). Similar to taxonomic composition, geographic position was less influential than catchment and site-scale variables for traits. Significant positive *Rv*-coefficients differences occurred between geophysical variables and site-scale variables describing in-stream cover (59% higher), hydromorphology (50%), and riparian canopy cover (39.7%) (Table 4). Significant positive *Rv*-coefficients differences occurred between land use and all site-scale variables suggesting a greater influence of land use (between 33.8% and 75.5%) on EPT trait composition.

**Table 4:** Results from the bootstraps performed on the differences between *Rv*-coefficients resulting from the comparison between EPT *trait* composition and geographic position, and catchment- and site-scale variables. *P*: probability that the observed difference $[Rv(E_1,F) - Rv(E_2,F)]$ is significantly positive. (n.s. = non significant).

| | Observed | P |
|---|---|---|
| Catchment – Geographic position | 0.066 | 0.001 |
| Site – Geographic position | 0.051 | 0.020 |
| Catchment – Site | 0.015 | 0.005 |
| Land use – In-stream cover | 0.105 | 0.001 |
| Land use – Morphology | 0.098 | 0.001 |
| Land use – Canopy cover | 0.089 | 0.001 |
| Land use – Substrate | 0.061 | 0.002 |
| Geophysical features – In-stream cover | 0.049 | 0.001 |
| Land use – Flow | 0.047 | 0.004 |
| Land use – Water Quality | 0.047 | 0.011 |
| Geophysical features – Hydromorphology | 0.042 | 0.002 |
| Geophysical features – Riparian canopy cover | 0.033 | 0.010 |
| Geophysical features – Substrate | 0.006 | n.s. |
| Geophysical features – Flow | -0.008 | n.s. |
| Geophysical features – Water quality | -0.009 | n.s. |
| Geophysical features – Land use | -0.056 | n.s. |

**Discussion**

Our aim was to assess the influence of environmental variables at varying spatial scales on taxonomic and trait composition of EPT assemblages found in neotropical savanna headwater streams. Both catchment- and site-scale variable groups equally influenced EPT taxon composition, and geographic position was less influential than both. Considering EPT trait composition, catchment-scale variables were more influential than site-scale variables, and geographic location was also less influential than the two groups. Substrate, hydromorphology, and land use were prominent in explaining the variation in EPT taxonomic composition whereas land use mainly explained the variation in EPT trait composition.

Traits such as relation to substrate and potential number of reproductive cycles per year best discriminated EPT assemblages. Substrate conditions are known to constrain invertebrate distribution and abundance in streams (Wood & Armitage, 1997; Rabení, Doisy & Zweig, 2005). Fine sediments have direct effects on benthic habitats and are key stressors for benthic invertebrates (Bryce et al., 2010), being a result of increased agricultural runoff, elimination of riparian vegetation, and channelization of streams (Wood & Armitage, 1997; Jones et al., 2012). Corroborating Rabení et al. (2005), we also observed that sprawlers were particularly intolerant to increased fine sediment and embeddedness. Assemblages with more multi-voltine organisms generally have a higher resilience to frequent disturbance. Our results corroborate the findings of Dolédec et al. (2006) who observed that the number of cycles per year of New Zealand stream invertebrates increased with the intensity of land use.

Environmental variables at both catchment- and site-scales explained significant amounts of variation in EPT taxon and trait composition. Although the relationship between catchment-scale variables and EPT taxon composition was generally higher than that observed between site-scale variables and EPT taxon composition (Fig. 6a), the overall difference between them was not significant. Hydromorphology, substrate, and land use accounted for most of the variation in EPT taxonomic composition. Hydromorphology characteristics such as stream size and mean wetted and bankfull width and depth particularly influenced the taxonomic composition of EPT assemblages. Stream size is the primary determinant of the amount of lotic habitat in a locality and modifications in channel dimensions change the quantity and quality of aquatic habitat (Kaufmann et al., 1999; Ligeiro et al., 2013). Furthermore, hydromorphological alterations are considered major stressors of lotic ecosystems and their biology (Vaughan et al., 2009), although the links between river ecology and hydromorphology are still incomplete (Feld, de Bello & Dolédec, 2014). In addition, percentage of fines, substrate diameter, and relative bed stability were important variables to the taxonomic composition of EPT assemblages. Bottom characteristics are often cited as major parameters that control macroinvertebrate composition (Rabení et al., 2005; Jones et al., 2012). Substrate size influences the hydraulic roughness and consequently the range of water velocities in a stream channel. It also influences the size range of interstices that provide living space and cover for aquatic assemblages (Kaufmann et al., 1999). Decreases in the mean substrate size and increases in the percentage of fine sediments may destabilize channels and indicate changes in the rates of upland erosion and sediment supply (Dietrich et al., 1989; Bryce et al., 2010). Additionally, substrate heterogeneity (i.e., proportion of different sediment types, sizes, or textures) allows more species to coexist and positively affects macroinvertebrate assemblage structure, acting as an abiotic filter that selects for a set of functionally different organisms (Milesi et al., 2016). In an earlier study conducted in the Nova Ponte and Três Marias HUs, Ferreira et al. (2014) pointed out the importance of site-scale physical habitat in the distribution of EPT richness and concluded that channel morphology (width and depth), riparian structure, substrate composition, and water quality were important for structuring macroinvertebrate richness in headwater streams. The percentage of natural cover influenced both the taxonomic and trait composition of EPT assemblages, the relation for traits being weaker than for taxa. Modifications of natural vegetation land cover can cause multiple influencing factors, including increased nutrients in the water, fine sediments in the streambed, chemical contamination, loss of habitat heterogeneity, and increased light availability and aquatic macrophyte growth through the clearing of riparian vegetation (Allan, 2004); Leitão et al., 2017).

Catchment-scale variables, mainly land use, were more influential on the trait composition of EPT assemblages in comparison with site-scale variables. In general, taxonomic structure should be more strongly affected by regional processes, whereas functional structure should be mostly shaped by site-scale characteristics (Hoeinghaus et al., 2007) because of their greater proximity and interaction with the organisms. However, a mismatch between patterns of taxonomic and functional structure may also be related to spatial scales. Large-scale processes shape the pool of species in a local assemblage. Sites may be located within a single regional species pool, then all species and functional trait combinations may colonize each site, and taxonomic and functional structure should exhibit similar patterns along major environmental gradients (Heino et al., 2007). The multiple spatial scales regulating assemblage structure are related to multiple environmental filters, where each spatial scale acts as an environmental filter and only species possessing a specific set of traits pass the filter at each scale and become established in a community (Tonn, 1990; Poff, 1997). In fact, land use influenced assemblages in our study through its effects on canopy cover, water quality, in-stream cover, flow, and hydromorphology. Such a high influence of land use induced stressors on the functional trait composition of stream macroinvertebrate assemblages supports the findings of previous studies (Richards et al. 1997; Dolédec et al. 2011).

We also observed that the correlations with environmental variables were generally lower for trait than for taxon composition of EPT assemblages at both spatial scales. In contrast, in New Zealand streams subjected to intensive land use, both taxonomy and trait approaches were able to discriminate land use practices, but the trait approach accounted for more variance between different land uses (Dolédec et al., 2006). However, this study may not be comparable to ours because the intensity of land use and the taxa differ. Nonetheless taxa that naturally fluctuate with environmental conditions and geography may have similar traits, thus smoothing the response of traits to environmental variation at larger scales. This higher spatial stability of traits is potentially linked to the physical harshness of the stream conditions, which act as a strong abiotic filter on biological traits and involves trait convergence in stream biota (e.g. Poff, 1997; Statzner et al., 2004).

Similar to the findings of Townsend et al. (2003), geographic position accounted for less assemblage variation than catchment- and site-scale variables for both taxa and traits. This suggests three alternative hypotheses. (i) Different species have evolved in an ecologically divergent way in the different locations not ignoring that geography and environmental variables may be correlated. (ii) EPT evolutionary history may have constrained the colonization of various locations. (iii) Weak dispersal capabilities of neotropical savanna EPT have prevented them from overcoming geographic barriers (see Townsend et al. 2003). However, our current lack of biological knowledge of Cerrado EPT taxa prevents us from confirming one or more of those hypotheses. Townsend et al. (2003) also observed a lower relationship between geographical location and invertebrate assemblage composition in comparison to catchment- and site-scale variables, possibly due to a correlation between geography and those environmental conditions.

To our knowledge, our study is the first that considers environmental variables at catchment and site scales to explain both invertebrate taxonomic and functional composition in tropical savanna streams. Our results demonstrate four key issues regarding those streams: i) Aquatic invertebrate taxonomic composition is mainly structured by land use, substrate, and hydromorphology. ii) Land use filters specific traits in EPT assemblages. iii) It is essential to increase our biological knowledge of invertebrates if we want to include the multiple-trait based approach in water resource conservation. iv) Identification of variables driving the taxonomic and functional structure of macroinvertebrate assemblages determines the scale at which efforts for protection and/or rehabilitation would best be directed to improve and/or maintain environmental and ecological condition.

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**Table S1:** Environmental variables and their codes and definitions. Average values and standard deviation (in parentheses) are given for each HU.

| Variables | Variable code | Hydrologic unit | | | |
|---|---|---|---|---|---|
| | | TM | VG | SS | NP |
| **Catchment scale** | | | | | |
| Geophysical features | | | | | |
| Drainage area (km²) | Dren_area | 46.26 (47.3) | 17.14 (16.33) | 30.42 (26.66) | 10.74 (10.71) |
| Site altitude (m) | Altitude | 659.94 (63.46) | 623.74 (66.93) | 485.43 (54.77) | 885.28 (41.97) |
| Range basin elevation (m) | Elev_range | 731.66 (78.42) | 723.74 (66.72) | 563.33 (51.5) | 968.08 (43.59) |
| Average basin elevation (m) | Elev_mean | 35.8 (20.72) | 171.18 (54.97) | 195.2 (73.61) | 149.18 (68.8) |
| Std. Dev. Basin elevation | Elev_std | 167.51 (89.04) | 37.11 (12.69) | 42.65 (21.09) | 34.23 (15.96) |
| Range basin slope (%) | Slope_range | 7.43 (3.23) | 6.03 (1.84) | 5.67 (1.87) | 8.24 (3.03) |
| Average basin slope (%) | Slope_mean | 4.98 (4.24) | 3.54 (1.45) | 4.55 (2.81) | 4.48 (1.58) |
| Std. Dev. Basin slope | Slope_std | 48.54 (92.72) | 22.91 (10.13) | 31.92 (17.78) | 23.78 (9.5) |
| Total annual rainfall (mm/m²) | Rainfall | 1299.23 (79.17) | 1536.08 (37.8) | 1464.11 (77.75) | 1564.09 (40.36) |
| Land Use | | | | | |
| % Woodland savanna | Woodland | 16.08 (13.14) | 12.23 (5.46) | 13.42 (6.41) | 15.09 (7.18) |
| % Parkland savanna | Parkland | 18.15 (18.92) | 0 (0) | 0.84 (2.29) | 9.56 (23.57) |
| % Grassy-woody savanna | Grassy_Woody | 10.56 (8.96) | 1.43 (1.47) | 1.51 (2.86) | 10.1 (14.3) |
| % Palm swamp | Palm_swamp | 1.39 (3.23) | 0.42 (1.16) | 2.48 (2.59) | 0.58 (1.29) |
| % Pasture use | Pasture | 41.24 (18.1) | 12.22 (10.68) | 10.4 (14.62) | 13.65 (17.29) |
| % Agricultural use | Agriculture | 3.07 (4.12) | 71.34 (14.24) | 68.2 (20.41) | 50.13 (29.9) |
| % Eucaliptus forest | Eucaliptus | 9.14 (11.17) | 0.21 (1.32) | 0.85 (1.64) | 0 (0) |
| % Natural land use | Natural | 46.17 (19.21) | 14.08 (5.35) | 18.25 (7.35) | 35.33 (25.15) |
| Distance to cities (km) | City_dist | 17.17 (10.38) | 11.81 (5.64) | 17.09 (7.69) | 15.68 (8.6) |
| Distance to paved highways (km) | Highway_dist | 5.31 (4.79) | 1.39 (0.8) | 2.93 (2.52) | 6.89 (4.77) |
| Density of homes in the basin (houses/km²) | House_density | 0.96 (2.62) | 12.53 (26.54) | 20.6 (115.83) | 8.42 (44.22) |
| **Site scale** | | | | | |
| Hydromorphology | | | | | |
| Site length (m) | Reachlen | 181.28 (62.88) | 165.53 (30.91) | 172.65 (47.65) | 151.5 (8.02) |
| Mean thalweg depth (cm) | depth_T | 42.21 (17.28) | 39.15 (16.9) | 36.19 (14.23) | 28.68 (16.48) |
| Mean wetted width (m) | width | 3.77 (2.34) | 3.7 (1.62) | 3.92 (2.08) | 2.54 (1.06) |
| Mean bankfull width (m) | BKF_W | 6.59 (3.61) | 6.11 (2.72) | 6.91 (3.18) | 4.72 (1.99) |
| Mean bankfull height (m) | BKF_H | 0.95 (0.34) | 0.96 (0.34) | 1.14 (0.37) | 0.89 (0.24) |
| Mean width x mean depth (m²) | WXD | 1.69 (1.49) | 1.56 (1.12) | 1.48 (1.02) | 0.78 (0.75) |
| Mean width/depth ratio (m/m) | WD_RAT | 9.88 (6.97) | 10.35 (4.66) | 11.85 (6.48) | 10.57 (5.23) |
| Mean bank angle (degrees) | BKA | 50.31 (21.78) | 44.34 (13.15) | 42.18 (12.54) | 37.71 (11.99) |
| Water surface gradient over site (%) | SLOPE | 0.01 (0.01) | 0.01 (0.01) | 0.01 (0.01) | 0.01 (0.01) |
| Channel sinuosity | SINU | 1.24 (0.07) | 1.22 (0.07) | 1.24 (0.08) | 1.19 (0.09) |
| Substrate | | | | | |
| Mean embeddedness (%) | EMBED | 57.87 (24.92) | 64.3 (14.61) | 59.16 (20.25) | 61.01 (19.98) |
| % bedrock (>4000 mm) | PCT_BDRK | 13.18 (21.18) | 8.33 (17.87) | 6.28 (14.29) | 2.81 (6.42) |
| % boulders (250 to 4000 mm) | PCT_BL | 11.89 (16.29) | 6.39 (8.08) | 3.98 (6.14) | 2.41 (3.84) |
| % cobble (64 to 250mm) | PCT_CB | 9.07 (12.95) | 10.07 (12.41) | 8.11 (9.91) | 6.82 (8.5) |
| % coarse gravel (16 to 64 mm) | PCT_GC | 2.88 (4.93) | 4.87 (8.81) | 6.32 (7.2) | 12.52 (13.26) |
| % fine gravel (2 to 16mm) | PCT_GF | 5.9 (12.67) | 12.69 (11.95) | 10.95 (10.71) | 16.53 (11.91) |

| Variables | | Variable code | Hydrologic unit | | | |
|---|---|---|---|---|---|---|
| | | | TM | VG | SS | NP |
| | % sand (0.6 to2 mm) | PCT_SA | 7.84 (11.32) | 14.01 (12.72) | 23.74 (25.61) | 19.05 (15.04) |
| | % fines (<0.6 mm) | PCT_FN | 32.36 (33.57) | 27.58 (22.64) | 17.05 (19.18) | 16.55 (18.79) |
| | % Organic matter | PCT_ORG | 14.53 (18.18) | 13.01 (13.32) | 19.21 (16.35) | 18.36 (11.86) |
| | % Large Wood | PCT_WD | 1.49 (3.33) | 1.38 (3.18) | 1.31 (2.24) | 0.33 (0.85) |
| | Log10 estimated geometric mean substrate diameter (mm) | LSUB_DMM | 0.28 (1.87) | 0.23 (1.25) | 0.24 (1.03) | 0.18 (1) |
| | Log10 - Relative Bed Stability (dimensionless: m/m)) | LRBS | -1.12 (1.64) | -1.34 (1.13) | -1.48 (1) | 0.08 (0.57) |
| Flow | | | | | | |
| | Flow - instantaneous discharge(m3/s) | FLOW_2 | 0.05 (0.08) | 0.29 (0.23) | 0.54 (1.27) | 0.12 (0.12) |
| | Velocity mean (m/s) | VEL | 0.05 (0.07) | 0.29 (0.15) | 0.93 (3.5) | 0.38 (0.31) |
| | % Glides | PCT_GL | 36.74 (30.58) | 59.75 (28.11) | 67.72 (21.97) | 65.13 (24.93) |
| | % rapids and riffles | PCT_FAST | 10.92 (12.34) | 35.25 (28.22) | 27.88 (20.7) | 26.38 (24.86) |
| | % pools | PCT_POOL | 52.33 (37.44) | 5 (12.71) | 4.4 (12.88) | 8.49 (14.83) |
| | Sequence fasts, glides and pools (1= maximum Heterogenity, 0= maximum homogeneity ) | SEQ_FLO_1 | 0.07 (0.06) | 0.06 (0.04) | 0.06 (0.04) | 0.07 (0.04) |
| Canopy cover | | | | | | |
| | Mean mid-channel canopy density (%) | CDENMID | 72.61 (25.01) | 78.27 (15.86) | 76.01 (24.44) | 84.85 (19.61) |
| | Mean canopy cover > 0.3m DBH | CL | 6.24 (8.56) | 9.96 (8.79) | 8.11 (7.13) | 13.64 (11.65) |
| | Mean canopy cover <= 0.3m DBH | CS | 12.57 (9.45) | 16.36 (11.4) | 19.53 (19.76) | 29.18 (19.11) |
| | Mean woody mid-layer cover | MW | 20.87 (12.08) | 25.44 (16) | 23.95 (16.01) | 29.08 (15.22) |
| | Mean herbaceous mid-layer cover | MH | 15.31 (11.95) | 15.21 (16.74) | 10.5 (10.36) | 16.93 (14.7) |
| | Mean woody ground-layer cover | GW | 12.66 (8.73) | 15.09 (11.12) | 12.83 (10.06) | 18.47 (13.25) |
| | Mean herbaceous ground-layer cover | GH | 27.03 (21.44) | 17.91 (14.36) | 21.05 (18) | 19.19 (15.33) |
| | Mean exposed soil | GB | 26.05 (16.8) | 18.06 (14.44) | 23.74 (16.42) | 14.63 (9.86) |
| | Mean riparian veg canopy cover | C | 18.81 (16.94) | 26.32 (17.29) | 27.64 (24.87) | 42.82 (28.24) |
| | Mean riparian veg mid-layer cover | M | 36.19 (20.1) | 40.65 (26.64) | 34.46 (21.46) | 46.01 (24.2) |
| | Mean riparian veg ground cover | G | 39.69 (22.22) | 33 (18.6) | 33.88 (21.56) | 37.66 (23.88) |
| In-stream cover | | | | | | |
| | Prop. Areal cover filamentous algae | FC_ALG | 5.11 (9.72) | 0.15 (0.92) | 3.16 (8.05) | 0.52 (1.98) |
| | Prop. Areal cover aquatic macrophytes | FC_AQM | 1.43 (4.3) | 0.5 (1.56) | 2.85 (10.47) | 2.86 (7.94) |
| | Prop. Areal cover large wood | FC_LWD | 3.81 (7.05) | 5.69 (8.59) | 3.13 (5.27) | 1.84 (2.82) |
| | Prop. Areal cover brush | FC_BRS | 7.07 (9.61) | 10.64 (10.21) | 11.56 (10.6) | 8.56 (6.4) |
| | Prop. Areal cover live trees | FC_ROT | 8.19 (10.31) | 12.75 (7.68) | 13.69 (15.56) | 20.07 (13.34) |

| Variables | Variable code | Hydrologic unit | | | |
|---|---|---|---|---|---|
| | | TM | VG | SS | NP |
| Prop. Areal cover leaf pack | FC_LEB | 20.49 (19.23) | 20.85 (19.85) | 17.06 (15.32) | 22.84 (17.43) |
| Prop. Areal cover undercut banks | FC_UCB | 3.63 (5.35) | 5.72 (5.7) | 5.84 (6.95) | 6.64 (6.88) |
| Prop. Areal cover boulders | FC_RCK | 18.05 (24.9) | 10.53 (16.5) | 10.97 (15.98) | 5.72 (8.13) |
| Water quality | | | | | |
| DO (mg/L) | OXY | 7.84 (2.67) | 8.74 (2.91) | 7.8 (1.15) | 7.86 (0.89) |
| pH | pH | 7.67 (0.5) | 7.5 (0.83) | 6.9 (0.53) | 6.82 (0.74) |
| Turbidity (UNT) | TURB | 6.36 (8.67) | 5.93 (4.53) | 6.88 (4.19) | 4.88 (5.8) |
| Conductivity(µS/cm) | COND | 63.67 (49.45) | 39.34 (17.35) | 68.71 (51.17) | 22.36 (15.11) |
| TDS (mg/L) | TDS | 42.1 (33.33) | 23.54 (15.65) | 38.59 (31.54) | 11.71 (7.63) |
| Water temp (°C) | TEMP | 17.23 (1.82) | 20.45 (1.26) | 20.25 (1.7) | 19.33 (1.66) |
| Total Nitrogen (mg/L) | NO3 | 0.08 (0.02) | 0.11 (0.03) | 0.1 (0.03) | 0.09 (0.02) |
| Alkalinity | ALCA | 0.02 (0.01) | 0.02 (0.02) | 0.01 (0.05) | 0.02 (0.03) |

**Table S2:** Results of co-inertia analyses performed between each set of environmental variables and EPT taxa (and trait) composition. *Rv*: correlation coefficient between tables, *P*: simulated probability equal to the frequency of random values higher that the observed *Rv*-coefficient.

| | % variance | | % environment | % EPT | Rv | P |
|---|---|---|---|---|---|---|
| **Taxa composition** | Axis 1 | Axis 2 | | | | |
| Geophysical features | 43.8 | 30.1 | 87.7 | 52.6 | 0.194 | 0.001 |
| Land use | 71.1 | 15.6 | 92.7 | 59.7 | 0.221 | 0.001 |
| Hydromorphology | 80.2 | 11.8 | 91.0 | 83.7 | 0.210 | 0.001 |
| Substrate | 80.4 | 9.2 | 98.2 | 83.1 | 0.237 | 0.001 |
| Flow | 79.6 | 11.3 | 98.9 | 40.4 | 0.181 | 0.001 |
| Riparian canopy cover | 55.9 | 26.3 | 92.5 | 24.8 | 0.077 | 0.002 |
| In-stream habitat cover | 63.5 | 15.6 | 79.6 | 72.8 | 0.150 | 0.001 |
| Water quality | 59.6 | 18.1 | 92.9 | 47.6 | 0.177 | 0.001 |
| **Trait composition** | | | | | | |
| Geophysical features | 60.5 | 29.7 | 81.0 | 85.5 | 0.083 | 0.001 |
| Land use | 82.2 | 13.8 | 86.8 | 93.8 | 0.139 | 0.001 |
| Hydromorphology | 50.9 | 34.5 | 77.1 | 42.3 | 0.041 | 0.057 |
| Substrate | 80.8 | 7.5 | 91.8 | 54.6 | 0.078 | 0.001 |
| Flow | 80.8 | 11.8 | 96.2 | 67.7 | 0.092 | 0.001 |
| Riparian canopy cover | 64.5 | 25.2 | 98.6 | 46.8 | 0.050 | 0.015 |
| In-stream habitat cover | 45.6 | 25.8 | 59.2 | 45.0 | 0.034 | 0.140 |
| Water quality | 69.9 | 23.6 | 65.6 | 80.5 | 0.092 | 0.001 |

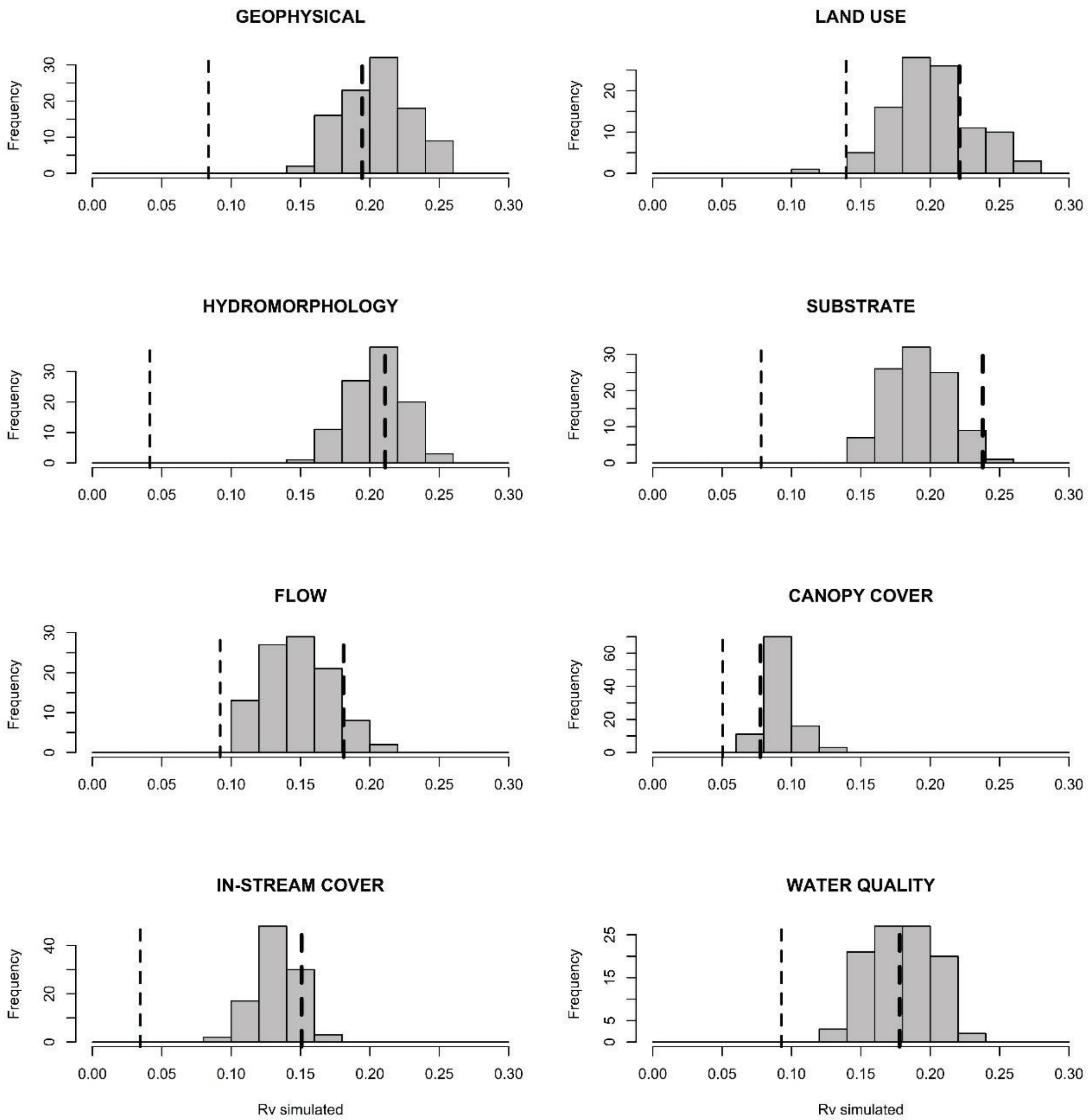


**Figure S1:** Observed (broken lines) and frequency of 100 simulated values (for 28 randomly selected genera, corresponding to the number of the 28 trait categories) of the variance explained by each group of environmental variables. First broken and thinner line: traits; second dotted and thicker line: taxonomy.

**Table S3:** Trait profiles (proportion) of 74 neotropical genera of Ephemeroptera, Plecoptera and Trichoptera for 28 categories in 7 biological traits.

| Genus | Body size | | | | | | Potencial number of cycles per year | | Feeding habits | | | | | Locomotion | | | | | Body flexibility | | | Body form | | | | Relation to substrate | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | <1.5 | 1.5 - 2.5 | 2.5 - 3.5 | 3.5 - 5.0 | 5.0 - 10.0 | >10 | < ou = 1 | > 1 | Collector-Gatherer | Shredder | Scraper | Collector-Filterer | Predator | Burrower | Climber | Sprawler | Clinger | Swimmer | <10° | >10-45° | >45° | Streamlined | Flattened | Cylindrical | Spherical | Free living | Silk-net builder | Case builder |
| **Ephemeroptera** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Americabaetis* | 0.03 | 0.48 | 0.35 | 0.1 | 0.05 | 0 | 0 | 1 | 0.4 | 0 | 0.6 | 0 | 0 | 0 | 0 | 0.29 | 0.29 | 0.43 | 0 | 0.25 | 0.75 | 0.25 | 0 | 0.75 | 0 | 1 | 0 | 0 |
| *Apobaetis* | 0.07 | 0.48 | 0.38 | 0.07 | 0 | 0 | 0 | 1 | 0.17 | 0.33 | 0.5 | 0 | 0 | 0 | 0 | 0.29 | 0.29 | 0.43 | 0 | 0.25 | 0.75 | 0.4 | 0 | 0.6 | 0 | 1 | 0 | 0 |
| *Askola* | 0 | 0.21 | 0.42 | 0.21 | 0.17 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0.24 | 0 | 0.38 | 0.08 | 0.3 | 0 | 0.47 | 0.53 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |
| *Asthenopus* | 0 | 0 | 0.04 | 0.27 | 0.58 | 0.11 | 1 | 0 | 0.4 | 0 | 0.2 | 0.4 | 0 | 0.75 | 0 | 0.25 | 0 | 0 | 0 | 0.25 | 0.75 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Aturbina* | 0.01 | 0.35 | 0.34 | 0.28 | 0.03 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0.29 | 0.29 | 0.43 | 0 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| *Baetodes* | 0.37 | 0.56 | 0.08 | 0 | 0 | 0 | 0 | 1 | 0.5 | 0 | 0.5 | 0 | 0 | 0 | 0 | 0.29 | 0.29 | 0.43 | 0 | 0 | 1 | 0.25 | 0 | 0.75 | 0 | 1 | 0 | 0 |
| *Caenis* | 0.07 | 0.39 | 0.38 | 0.14 | 0.03 | 0 | 0 | 1 | 0.6 | 0 | 0.4 | 0 | 0 | 0.29 | 0 | 0.43 | 0.29 | 0 | 0 | 0.5 | 0.5 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| *Callibaetis* | 0 | 0.11 | 0.23 | 0.25 | 0.41 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0.4 | 0.6 | 0 | 0.25 | 0.75 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Camelobaetidius* | 0.06 | 0.13 | 0.31 | 0.18 | 0.32 | 0 | 0 | 1 | 0.5 | 0 | 0.5 | 0 | 0 | 0.13 | 0 | 0.25 | 0.25 | 0.38 | 0 | 0.33 | 0.67 | 0.4 | 0 | 0.6 | 0 | 1 | 0 | 0 |
| *Campsurus* | 0.02 | 0.08 | 0.12 | 0.15 | 0.54 | 0.09 | 1 | 0 | 0.67 | 0 | 0 | 0.33 | 0 | 0.75 | 0 | 0.25 | 0 | 0 | 0 | 0.25 | 0.75 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Campylocia* | 0 | 0 | 0 | 0.1 | 0.35 | 0.55 | 0.22 | 0.78 | 0.17 | 0.33 | 0 | 0.5 | 0 | 0.43 | 0 | 0.29 | 0.29 | 0 | 0 | 0.5 | 0.5 | 0.6 | 0 | 0.4 | 0 | 1 | 0 | 0 |
| *Cloeodes* | 0.02 | 0.47 | 0.33 | 0.16 | 0.02 | 0 | 0 | 1 | 0.4 | 0 | 0.6 | 0 | 0 | 0 | 0 | 0.43 | 0.29 | 0.29 | 0 | 0.25 | 0.75 | 0.4 | 0 | 0.6 | 0 | 1 | 0 | 0 |
| *Cryptonympha* | 0 | 0.31 | 0.38 | 0.31 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0.14 | 0 | 0.29 | 0.29 | 0.29 | 0 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| *Farrodes* | 0.06 | 0.44 | 0.3 | 0.16 | 0.03 | 0 | 0 | 1 | 0.5 | 0 | 0.5 | 0 | 0 | 0 | 0 | 0.29 | 0.29 | 0.43 | 0 | 0 | 1 | 0.25 | 0.75 | 0 | 0 | 0 | 1 | 0 |
| *Guajirolus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0.4 | 0 | 0.6 | 0 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| *Hagenulopsis* | 0.15 | 0.35 | 0.26 | 0.2 | 0.04 | 0 | 0.4 | 0.6 | 0.5 | 0 | 0.5 | 0 | 0 | 0.67 | 0 | 0.33 | 0 | 0 | 0 | 0.47 | 0.53 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |
| *Hermanella* | 0 | 0.27 | 0.18 | 0.36 | 0.18 | 0 | 0.4 | 0.6 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0.4 | 0 | 0.6 | 0 | 0.47 | 0.53 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |
| *Hexagenia* | 0 | 0.17 | 0 | 0.5 | 0.33 | 0 | 1 | 0 | 0.75 | 0 | 0 | 0.25 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0.5 | 0.5 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Hydrosmilodon* | 0.02 | 0.21 | 0.29 | 0.36 | 0.12 | 0 | 1 | 0 | 0.4 | 0 | 0.6 | 0 | 0 | 0.75 | 0 | 0.25 | 0 | 0 | 0 | 0.47 | 0.53 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |
| *Latineosus* | 0.12 | 0.45 | 0.14 | 0.19 | 0.1 | 0 | 0 | 1 | 0.6 | 0 | 0.4 | 0 | 0 | 0.4 | 0 | 0.6 | 0 | 0 | 0 | 0.5 | 0.5 | 0 | 0.5 | 0.5 | 0 | 1 | 0 | 0 |
| *Leptohyphes* | 0.22 | 0.42 | 0.24 | 0.09 | 0.03 | 0 | 1 | 0 | 0.5 | 0.17 | 0.33 | 0 | 0 | 0.29 | 0 | 0.43 | 0.29 | 0 | 0 | 0.5 | 0.5 | 0.17 | 0.5 | 0.33 | 0 | 1 | 0 | 0 |
| *Leptohyphodes* | 0 | 0 | 0.07 | 0.14 | 0.79 | 0 | 0 | 1 | 0.5 | 0.17 | 0.33 | 0 | 0 | 0.29 | 0 | 0.43 | 0.29 | 0 | 0 | 0.5 | 0.5 | 0.2 | 0.4 | 0.4 | 0 | 1 | 0 | 0 |
| *Massartella* | 0 | 0.09 | 0.06 | 0.21 | 0.42 | 0.23 | 0.4 | 0.6 | 0.41 | 0.04 | 0.54 | 0.01 | 0 | 0.24 | 0 | 0.38 | 0.08 | 0.3 | 0 | 0.47 | 0.53 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |
| *Miroculis* | 0.02 | 0.27 | 0.26 | 0.32 | 0.14 | 0 | 0 | 1 | 0.5 | 0 | 0.5 | 0 | 0 | 0 | 0 | 0.5 | 0 | 0.5 | 0 | 0.47 | 0.53 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |
| *Paracloeodes* | 0.02 | 0.38 | 0.35 | 0.24 | 0.01 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0.5 | 0.17 | 0.33 | 0 | 0.25 | 0.75 | 0.4 | 0 | 0.6 | 0 | 1 | 0 | 0 |
| *Paramaka* | 0 | 1 | 0 | 0 | 0 | 0 | 0.4 | 0.6 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0.6 | 0 | 0.4 | 0 | 0.47 | 0.53 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |
| *Rivudiva* | 0 | 0.13 | 0.39 | 0.48 | 0 | 0 | 0 | 1 | 0.5 | 0 | 0.5 | 0 | 0 | 0 | 0 | 0.5 | 0.17 | 0.33 | 0 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| *Simothraulopsis* | 0 | 0 | 0.11 | 0.33 | 0.56 | 0 | 0.4 | 0.6 | 0.4 | 0 | 0.6 | 0 | 0 | 0 | 0 | 0.5 | 0 | 0.5 | 0 | 0.47 | 0.53 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |
| *Spiritiops* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0.2 | 0.2 | 0.6 | 0 | 0 | 0 | 0 | 0 | 0.4 | 0.6 | 0 | 0.25 | 0.75 | 0.5 | 0 | 0.5 | 0 | 1 | 0 | 0 |
| *Terpides* | 0 | 0.09 | 0.16 | 0.28 | 0.47 | 0 | 0.4 | 0.6 | 0.38 | 0.38 | 0.25 | 0 | 0 | 0.43 | 0 | 0.29 | 0.14 | 0.14 | 0 | 0.67 | 0.33 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |
| *Thraulodes* | 0.05 | 0.33 | 0.31 | 0.18 | 0.12 | 0 | 1 | 0 | 0.43 | 0 | 0.43 | 0.14 | 0 | 0.33 | 0 | 0.22 | 0.33 | 0.11 | 0 | 0.75 | 0.25 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |

| Genus | Body size | | | | | | Potencial number of cycles per year | | Feeding habits | | | | | Locomotion | | | | | Body flexibility | | | Body form | | | | Relation to substrate | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | <1.5 | 1.5 - 2.5 | 2.5 - 3.5 | 3.5 - 5.0 | 5.0 - 10.0 | >10 | < ou = 1 | > 1 | Collector-Gatherer | Shredder | Scraper | Collector-Filterer | Predator | Burrower | Climber | Sprawler | Clinger | Swimmer | <10° | >10-45° | >45° | Streamlined | Flattened | Cylindrical | Spherical | Free living | Silk-net builder | Case builder |
| *Traverhyphes* | 0.08 | 0.36 | 0.32 | 0.22 | 0.01 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0.29 | 0 | 0.43 | 0.29 | 0 | 0 | 0.5 | 0.5 | 0.2 | 0.4 | 0.4 | 0 | 1 | 0 | 0 |
| *Tricorythodes* | 0.11 | 0.28 | 0.39 | 0.2 | 0.03 | 0 | 0 | 1 | 0.75 | 0 | 0.25 | 0 | 0 | 0.29 | 0 | 0.43 | 0.29 | 0 | 0 | 0.5 | 0.5 | 0.2 | 0.4 | 0.4 | 0 | 1 | 0 | 0 |
| *Tricorythopsis* | 0.19 | 0.77 | 0.04 | 0 | 0 | 0 | 0 | 1 | 0.75 | 0 | 0.25 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0.5 | 0.5 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |
| *Ulmeritoides* | 0.03 | 0.25 | 0.18 | 0.21 | 0.33 | 0.01 | 1 | 0 | 0.41 | 0.04 | 0.54 | 0.01 | 0 | 0.24 | 0 | 0.38 | 0.08 | 0.3 | 0 | 0.47 | 0.53 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |
| *Varipes* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0.5 | 0.17 | 0.33 | 0 | 0 | 0 | 0 | 0.17 | 0.33 | 0.5 | 0 | 0 | 1 | 0.25 | 0 | 0.75 | 0 | 1 | 0 | 0 |
| *Waltzoyphius* | 0.02 | 0.17 | 0.31 | 0.4 | 0.11 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0.43 | 0.29 | 0.29 | 0 | 0.25 | 0.75 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Zelusia* | 0.09 | 0.43 | 0.3 | 0.16 | 0.02 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0.38 | 0.25 | 0.38 | 0 | 0.25 | 0.75 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| **Plecoptera** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Anacroneuria* | 0.04 | 0.15 | 0.23 | 0.2 | 0.28 | 0.09 | 0 | 1 | 0.2 | 0.2 | 0 | 0 | 0.6 | 0 | 0 | 0.5 | 0.33 | 0.17 | 0.5 | 0.5 | 0 | 0.33 | 0.67 | 0 | 0 | 1 | 0 | 0 |
| *Grypopteryx* | 0.12 | 0.47 | 0.06 | 0.18 | 0.18 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0.25 | 0.5 | 0.25 | 0.5 | 0.5 | 0 | 0.78 | 0.22 | 0 | 0 | 1 | 0 | 0 |
| *Kempnya* | 0 | 0 | 0 | 0.2 | 0.6 | 0.2 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0.5 | 0.5 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Paragrypopteryx* | 0.12 | 0.74 | 0.14 | 0 | 0 | 0 | 1 | 0 | 0.33 | 0.33 | 0.33 | 0 | 0 | 0 | 0 | 0.25 | 0.5 | 0.25 | 0.5 | 0.5 | 0 | 0.78 | 0.22 | 0 | 0 | 1 | 0 | 0 |
| *Tupiperla* | 0.01 | 0.2 | 0.35 | 0.27 | 0.17 | 0 | 1 | 0 | 0.33 | 0.33 | 0.33 | 0 | 0 | 0 | 0 | 0.25 | 0.5 | 0.25 | 0.5 | 0.5 | 0 | 0.78 | 0.22 | 0 | 0 | 1 | 0 | 0 |
| **Trichoptera** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Alisotrichia* | 0.58 | 0.33 | 0 | 0 | 0.08 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0.75 | 0.25 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Anchitrichia* | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0.75 | 0.25 | 0 | 0.51 | 0.14 | 0.35 | 0 | 0 | 0 | 1 |
| *Atanatolia* | 0.14 | 0 | 0.14 | 0.43 | 0.29 | 0 | 1 | 0 | 0.07 | 0.36 | 0.32 | 0 | 0.25 | 0 | 0 | 1 | 0 | 0 | 0.75 | 0.25 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Atopsyche* | 0 | 0.17 | 0.24 | 0.28 | 0.29 | 0.03 | 1 | 0 | 0 | 0.25 | 0 | 0 | 0.75 | 0 | 0 | 0.43 | 0.43 | 0.14 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| *Austrotinodes* | 0 | 0.09 | 0.28 | 0.37 | 0.26 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0.5 | 0.5 |
| *Barypenthus* | 0 | 0 | 0 | 0.19 | 0.25 | 0.56 | 1 | 0 | 0.43 | 0.29 | 0.29 | 0 | 0 | 0 | 0 | 0.6 | 0.4 | 0 | 0.75 | 0.25 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Chimarra* | 0 | 0.11 | 0.19 | 0.23 | 0.37 | 0.1 | 1 | 0 | 0 | 0.25 | 0 | 0.75 | 0 | 0 | 0 | 0.5 | 0.5 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Cyrnelus* | 0 | 0.11 | 0.11 | 0.33 | 0.44 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Grumichella* | 0 | 0 | 0 | 1 | 3 | 0 | 0 | 0 | 2 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 3 | 1 | 0 | 0 | 0 | 3 | 0 | 0 | 1 | 3 |
| *Helicopsyche* | 0 | 0.18 | 0.43 | 0.33 | 0.08 | 0 | 0 | 1 | 0.6 | 0 | 0.4 | 0 | 0 | 0 | 0 | 0.5 | 0.5 | 0 | 0.75 | 0.25 | 0 | 0 | 0 | 0 | 1 | 0 | 0.25 | 0.75 |
| *Hydroptila* | 0.17 | 0.76 | 0.06 | 0.01 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0.5 | 0.5 | 0 | 0.75 | 0.25 | 0 | 0.67 | 0.33 | 0 | 0 | 0 | 0 | 1 |
| *Itaura* | 0.1 | 0.62 | 0.26 | 0.01 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0.25 | 0.75 | 0 | 0 | 0.4 | 0.6 |
| *Leptonema* | 0 | 0 | 0.12 | 0.05 | 0.13 | 0.7 | 0 | 1 | 0 | 0.2 | 0 | 0.6 | 0.2 | 0 | 0 | 0.33 | 0.5 | 0.17 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Macronema* | 0 | 0.12 | 0.05 | 0.16 | 0.26 | 0.41 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Macrostemun* | 0 | 0.08 | 0.08 | 0.15 | 0.23 | 0.46 | 1 | 0 | 0 | 0.13 | 0 | 0.73 | 0.13 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0.5 | 0.5 |
| *Marilia* | 0.01 | 0.09 | 0.23 | 0.27 | 0.39 | 0.01 | 1 | 0 | 0.38 | 0.13 | 0.38 | 0 | 0.13 | 0 | 0.5 | 0.5 | 0 | 0 | 0.75 | 0.25 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Metrichia* | 0.4 | 0.53 | 0.07 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0.75 | 0.25 | 0 | 0 | 0.5 | 0.5 | 0 | 0 | 0 | 1 |
| *Mortoniella* | 0.1 | 0.7 | 0.2 | 0 | 0 | 0 | 1 | 0 | 0.5 | 0 | 0.5 | 0 | 0 | 0 | 0 | 0.5 | 0.5 | 0 | 0.75 | 0.25 | 0 | 0 | 0.17 | 0.5 | 0.33 | 0 | 0.4 | 0.6 |
| *Nectopsyche* | 0.02 | 0.28 | 0.21 | 0.28 | 0.21 | 0 | 1 | 0 | 0.29 | 0.43 | 0.29 | 0 | 0 | 0 | 0.17 | 0.5 | 0.33 | 0 | 0.75 | 0.25 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Neotrichia* | 0.71 | 0.29 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0.5 | 0.5 | 0 | 0.75 | 0.25 | 0 | 0.4 | 0 | 0.6 | 0 | 0 | 0 | 1 |

| | Body size | | | | | | Potencial number of cycles per year | | Feeding habits | | | | | Locomotion | | | | | Body flexibility | | | Body form | | | | Relation to substrate | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Genus | <1.5 | 1.5 - 2.5 | 2.5 - 3.5 | 3.5 - 5.0 | 5.0 - 10.0 | >10 | < ou = 1 | > 1 | Collector-Gatherer | Shredder | Scraper | Collector-Filterer | Predator | Burrower | Climber | Sprawler | Clinger | Swimmer | <10° | >10-45° | >45° | Streamlined | Flattened | Cylindrical | Spherical | Free living | Silk-net builder | Case builder |
| *Notalina* | 0.22 | 0.11 | 0.11 | 0.22 | 0.33 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0.75 | 0.25 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Nyctiophylax* | 0.11 | 0.67 | 0.11 | 0 | 0 | 0.11 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Oecetis* | 0.1 | 0.31 | 0.34 | 0.2 | 0.05 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0.5 | 0.5 | 0 | 0.75 | 0.25 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Oxyetira* | 0.05 | 0.66 | 0.24 | 0.06 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0.5 | 0.5 | 0 | 0 | 0.75 | 0.25 | 0 | 0.5 | 0 | 0.5 | 0 | 0 | 0 | 1 |
| *Phylloicus* | 0.05 | 0.21 | 0.19 | 0.13 | 0.3 | 0.11 | 0 | 1 | 0.25 | 0.75 | 0 | 0 | 0 | 0 | 0 | 0.75 | 0.25 | 0 | 0.75 | 0.25 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Polycentropus* | 0 | 0.12 | 0.19 | 0.27 | 0.41 | 0.02 | 1 | 0 | 0 | 0.2 | 0 | 0.2 | 0.6 | 0 | 0 | 0.5 | 0.5 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Polyplectropus* | 0 | 0.01 | 0.09 | 0.24 | 0.66 | 0 | 1 | 0 | 0 | 0.07 | 0 | 0.4 | 0.53 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Protoptila* | 0.05 | 0.47 | 0.34 | 0.14 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0.5 | 0.5 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0.4 | 0.6 |
| *Smicridea* | 0 | 0.25 | 0.25 | 0.24 | 0.24 | 0 | 0 | 1 | 0 | 0.2 | 0 | 0.6 | 0.2 | 0 | 0 | 0.33 | 0.5 | 0.17 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Triplectides* | 0 | 0.07 | 0.07 | 0.1 | 0.5 | 0.27 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0.75 | 0.25 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Wormaldia* | 0 | 0.91 | 0 | 0.03 | 0.06 | 0 | 1 | 0 | 0 | 0 | 0.4 | 0.6 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |

# Chapter III

# Land cover disturbance homogenizes aquatic insect trait composition in savanna streams

Chapter 3 is a version of a manuscript in coauthoring with Sylvain Dolédec and Marcos Callisto.

# Land cover disturbance homogenizes aquatic insect trait composition in savanna streams

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## Highlights

- We assessed the influence of human-induced disturbances on the taxonomic and trait composition of Neotropical aquatic invertebrates.

- Aquatic assemblages in least disturbed streams were highly specialized, whereas assemblages in disturbed streams demonstrated functional homogenization.

- Riparian canopy cover was the main driver of the functional trait composition of least disturbed streams.

## Abstract

By modifying local habitat conditions, the alteration of land cover results in potentially severe faunal impairment, which subsequently affects ecosystem function. We analyzed changes in the composition of Ephemeroptera, Plecoptera and Trichoptera (EPT) assemblages along a gradient of human disturbance intensity in 186 Neotropical savanna headwater streams. Whereas EPT genus richness did not differ among the levels of disturbance, functional richness and diversity significantly decreased from least to highly disturbed streams. Using a combination of RLQ and fourth-corner analyses, we found that 12 of 28 trait categories were significantly associated with changes in land use and cover intensity across the catchment, local physical habitat and water quality. The proportion of individuals with large body size and low body flexibility with <1 reproductive cycle per year, building case, and climbing characterized EPT assemblages of least disturbed streams. In addition, least disturbed streams demonstrated

high community specialization compared with disturbed streams. To our knowledge, this study is the first that examines the response of invertebrate functional trait composition and diversity along a gradient of human disturbance at a large spatial scale in the Neotropics, thus demonstrating the applicability of multiple trait-based approaches.

**Key-words:** functional diversity, multiple traits, aquatic invertebrates, biotic homogenization.

## Introduction

Human pressures related to agriculture and land cover modifications are the main drivers of ecological worsening of stream and river ecosystems, primarily due to increases in nutrients and sedimentation and hydromorphological alterations (Carpenter et al., 2011; Dudgeon et al., 2006; Vörösmarty et al., 2010). These changes have led to the simplification of habitats and reduced the diversity of aquatic communities, imperiling the ecological integrity and the sustainability of ecological processes and associated ecosystem services (Cardinale et al., 2012; Hooper et al., 2005). Furthermore, multiple human pressures yield taxonomic and functional losses in assemblages through the reduction of the number of specialized species (Mondy and Usseglio-Polatera, 2014). Ecological specialization refers to the limitation in ecological niche space used by a species due to its specific traits (Futuyma and Moreno, 1988). As a result, homogenization at the community level limits the functions provided by the community and their ability to respond to human pressures, which may lead to the alteration of ecosystem functioning and services (Clavel et al., 2011; Petsch, 2016).

Functional traits are morphological, physiological, or behavioral characteristics that are expressed in the phenotypes of individuals and considered relevant to their ecological requirement and/or their effects on ecosystem properties (Violle et al., 2007). Trait-based approaches have been successfully used to assess the effects of human pressures on aquatic invertebrate communities (e.g., Dolédec et al., 1999; Culp et al. 2011;Gutiérrez-Cánovas et al., 2015; Piló et al., 2016) with the following advantages: (i) biological trait responses are spatially stable in least-disturbed situations (e.g., Statzner et al. 2004; Bonada et al., 2007), which potentially offer a more reliable assessment of ecological integrity compared with the use taxonomic composition that naturally varies across large spatial scales; (ii) biological traits allow a more mechanistic understanding to identify the causes of changes in communities (e.g., Dolédec et al., 2011; Verberk et al., 2013); and (iii) biological traits respond to a broad range of stressors in a predictable manner (e.g., Dolédec et al., 1999; Usseglio & Beisel 2002; Culp et al., 2011; Mondy & Usseglio, 2014; Mouillot et al., 2013).

In the Neotropics, the main human disturbances include habitat fragmentation and land cover conversion for agricultural purposes (Overbeck et al., 2015; Hunke et al., 2015), leading to several consequences for stream environments, such as reduced water quality, excess bottom siltation, altered flow regimes, and changes in stream channel structure (Allan et al., 1997; Leal et al., 2016). In other regions, authors have demonstrated that not only the composition and richness but also the trait composition of benthic invertebrate assemblages is affected by human disturbances (e.g., Archaimbault et al., 2010; Mondy *et al*., 2016; Ding et al., 2017). Neotropical savanna (Cerrado biome), the second largest biome in Brazil and a biodiversity hotspot (Myers et al., 2000), encompasses three of the largest watersheds in South America. Despite its enormous importance for freshwater species conservation and the provision of ecosystem services (Strassburg et al., 2017), the effects of human disturbances in the functional structure of aquatic invertebrate assemblages have been largely overlooked given that research and conservation efforts are very limited. Therefore, assessing changes in trait composition may facilitate disentangling the effects of disturbance on species assemblages (Leitão et al., 2017) and understanding how human disturbances affect the functional structure of aquatic assemblages.

As a result, we made *a priori* predictions on the potential response of the trait composition of benthic invertebrate assemblages to land cover alteration (e.g., deforestation) and the associated impairment of the hydromorphology (e.g., sedimentation and flow regime) and stream water quality (e.g., increase in nutrient inputs). Direct effects of riparian vegetation cover removal include the reduction of litter input, which should subsequently limit the proportion of shredders. Indirect effects of riparian vegetation cover removal include more frequent flow disturbances, which should involve a selection of organisms with traits conferring resilience, such as small size and several reproduction cycles per year (multivoltinism), and resistance capabilities (streamlined/flattened shape and crawling locomotion). In addition, changing land cover for agricultural purposes may directly involve an increase in sediment deposition, which should favor burrowers and potentially lead to flow reduction (i.e., due to water abstraction), which should favor swimmers. Finally, changes in water quality associated with organic contamination should favor filter feeders and collector gatherers, and the associated expansion of biofilms should favor scrapers (Table 1). Although we make individual predictions, we are aware that traits correlate in organisms (Verberck et al., 2013).

**Table 1.** Predictions for trait category responses to human impacts. Impacts may decrease (↓) or increase (↑) the relative abundance of a single trait category (after Statzner and Bêche 2010 and Feio and Dolédec 2012).

| Impact type | Effect | Trait response | Rationale |
|---|---|---|---|
| Riparian canopy cover changes | Removal of riparian vegetation cover | ↓ Shredders<br>↑ Scrapers | Decreased leaf litter input and increased autochthonous primary production |
| Hydromorphological changes | More frequent flow disturbance | ↑ Small size<br>↑ Multivoltinism<br>↑ Streamlined/flattened<br>↑ Crawling | Better resilience capacity of smaller sizes and more reproductive cycles |
| | Increased bottom siltation | ↑ Burrowers<br>↑ High body flexibility<br>↑ Collectors-gatherers | Use of substrate as refuge<br>Increased deposition of dissolved organic matter in pools |
| Flow constraints | Flow reduction | ↑ Swimmers | Release from flow action in remnant pools |
| Organic contamination | Organic matter input | ↑ Filter-feeders<br>↑ Collector-gatherers<br>↑ Scrapers | Food web changes due to increase in organic matter in suspension and more-abundant periphyton algae and biofilms |

We designed our study using Ephemeroptera, Plecoptera and Trichoptera (EPT) assemblages to assess the following: (1) potential differences in reliability between taxonomic and trait composition of aquatic insect assemblages to depict human disturbance in the Neotropics similar to those observed elsewhere (e.g., Dolédec et al. 1999); and (2) whether human disturbances also altered community specialization. We hypothesized that (1) because taxa possess traits that confer different sensitivities to land cover alteration intensity and associated hydromorphological degradation, one would expect a selection of specific co-adapted traits within benthic assemblages, and (2) the more diversified habitat conditions in least-disturbed streams should result in higher taxonomic richness, functional diversity and community specialization compared with streams affected by anthropogenic stressors.

## Methods

### *Study area*

We conducted our study in wadeable streams located in the Neotropical savanna (Cerrado biome) of southeastern Brazil. A total of 160 sites (1st- to 3rd-order streams sensu Strahler (1957), defined at a 1:100,000 scale) were sampled in four hydrological units (defined as the contributing drainage areas within 35 km upstream of each of four major hydropower reservoirs) of Nova Ponte, Três Marias, Volta Grande and São Simão (Fig. 1), comprising a total geographic area of 45,180 km². Site details are available in Ferreira et al. (2017) and Firmiano et al. (2017). A set of 26 sites representing least disturbed conditions was additionally sampled in the Nova Ponte hydrological unit (Martins et al. 2017). As recommended by other authors (Hughes et al., 1986; Stoddard et al., 2006), we assessed the good ecological condition at sites based on the minimal human disturbance in the catchment, the absence of direct local influence of human alterations, and the presence of native riparian vegetation at sampling sites.

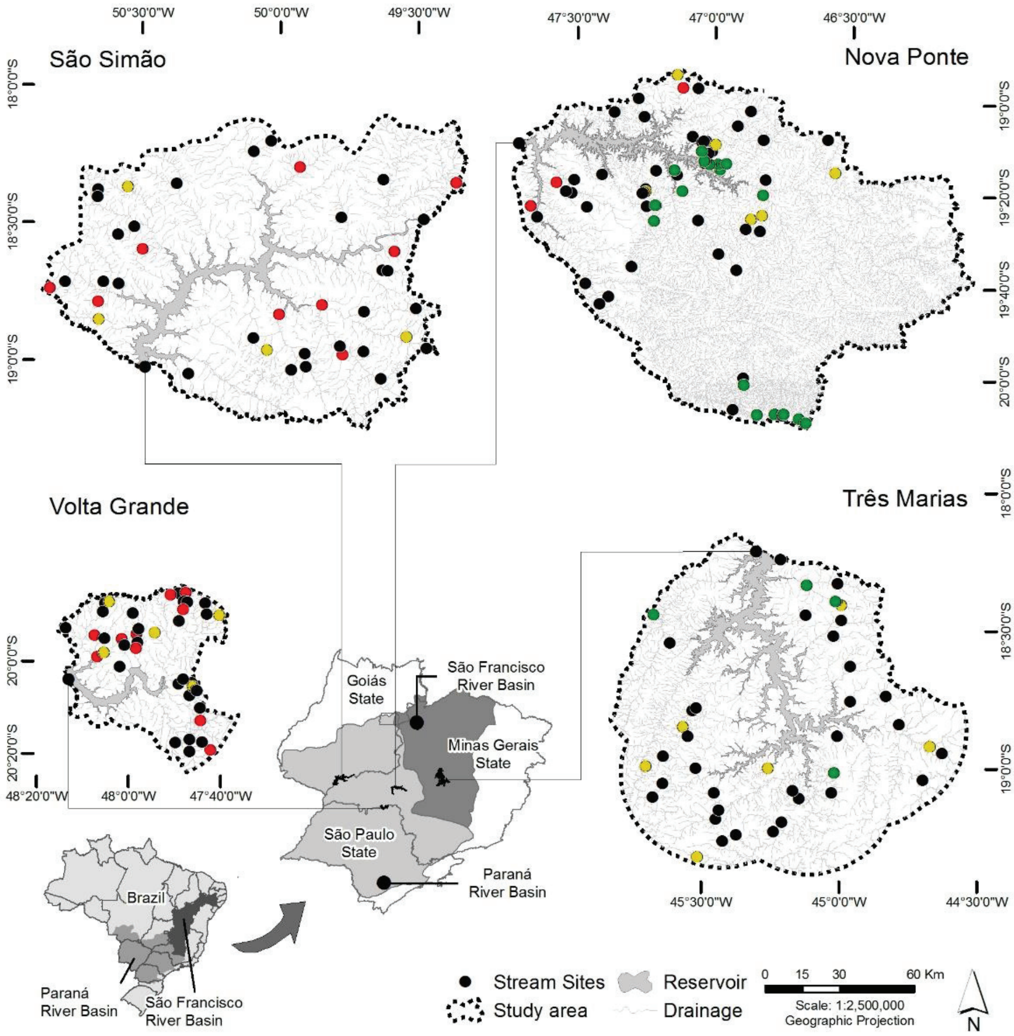


**Fig. 1.** Locations of wadeable stream sites (n=186) in four hydrological units in the Neotropical savanna, Minas Gerais state, southeastern Brazil. Green circles represent least disturbed streams, yellow circles represent intermediately disturbed streams, and red circles represent disturbed sites.

*Site selection*

We ranked sites from least to most disturbed based on the Integrated Disturbance Index (IDI) developed by Ligeiro et al. (2013). At each site, we measured human activities at local (LDI – Local Disturbance Index) and catchment (CDI – Catchment Disturbance Index) scales and analyzed both scales together through IDI. Briefly, CDI measures land uses in the catchment using a weighted average procedure. Urban areas receive a higher weight than agricultural areas, which receive a higher weight than pasture. LDI is based on the presence of local human pressures (garbage, sewages, buildings, domestic animals, row crops, pasture, erosion and dams) at each site (see Kaufmann et al., 1999). IDI scores were ranked (Table A1), and we calculated the mean and standard deviation (SD) of the IDI distribution to define the limits of least and most disturbed sites. Least and most disturbed sites were assessed as those deviating from the mean by -1SD and +1SD, respectively. The intermediately disturbed sites were those that occurred between these values.

After eliminating five sites with a genus richness <4, we retained 37 sites classified as least disturbed (IDI <0.21), 22 as disturbed (IDI >0.63) and 122 classified as intermediately disturbed (>0.21 and <0.63). To respect an equal number of sites across human disturbance levels, we randomly selected 22 sites among the least disturbed sites and 22 among the intermediately disturbed sites (Fig. 2). Following this random selection, we eliminated those sites with IDI values close to boundaries. Therefore, we analyzed a total of 66 sites with 22 sites in each level of human disturbance (least, intermediate, and most).

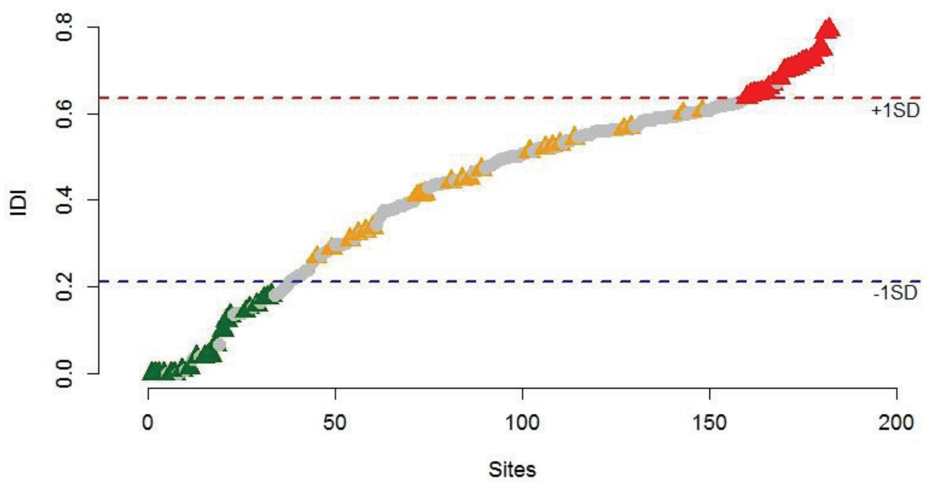


**Fig. 2.** Cumulative ranking of 181 stream sites from low to high values of human pressure based on the Integrated Disturbance Index (IDI). The mean and standard deviation of the IDI distribution was calculated and defined the least-disturbed and disturbed sites, respectively, as those deviating from the mean by -1SD (blue dotted line) and +1SD (red dotted lined). Green triangles represent the least disturbed streams, yellow triangles represent intermediately disturbed streams, and red triangles represent disturbed sites.

*Environmental variables*

Environmental variables at each site were described in terms of land use and cover, riparian canopy cover, physical habitat (habitat hydromorphology, substrate size, flow regime, in-stream habitat cover), and water quality (Table A2). Sites were described by a set of 61 environmental metrics (see Castro et al. in revision for further details) (Table A2).

*Sampling and biological traits*

Benthic macroinvertebrates were sampled with a D-frame kick net (30 cm aperture, 500 µm mesh). Eleven sub-sample units were taken at each stream following a systematic zig-zag trajectory along the site, generating one composite sample for each site (see Firmiano et al. (2017) for further details). Identification keys at genus or species levels remain limited for Neotropical macroinvertebrates (Moya et al., 2011), and the use of family level identification can lead to the loss of potentially important ecological information (Tomanova et al., 2008). Therefore, we restricted our study to Ephemeroptera, Plecoptera and Trichoptera (EPT) assemblages, given that they are the most studied groups of aquatic invertebrates in the Neotropics. In the laboratory, EPT individuals were identified at the genus level using various taxonomic keys (e.g., Dominguez et al., 2006; Mugnai et al., 2010; Pes et al., 2005). EPT abundances were log-transformed [ln(x+1)] to reduce the effect of dominant species and approximate a normal distribution.

In the Neotropics, the use of multiple trait-based (MTB) approaches is still in the beginning. One important limitation of the use of MTB approaches involves the difficulty to identify information on biological traits, which are lacking for a majority of Neotropical aquatic invertebrate species. We used a trait database recently developed for Neotropical macroinvertebrates fully described in Castro et al. in revision (Table A3). This database contains biological traits and their respective trait categories describing EPT genus profiles in terms of morphology, life cycle, resilience or resistance ability to natural disturbance or human disturbance, and feeding behavior (Table 2).

**Table 2.** Traits and their categories and codes used for 73 EPT genera collected in Neotropical savanna streams.

| Trait | Code | Category |
|---|---|---|
| Body size (mm) | less_1.5 | <1.5 |
| | bet_1.5_2.5 | >1.5 - 2.5 |
| | bet_2.5_3.5 | >2.5 - 3.5 |
| | bet_3.5_5 | >3.5 - 5.0 |
| | bet_5_10 | >5.0 - 10.0 |
| | more_10 | >10 |
| Potential number of reproductive cycles per year | less_1y | ≤ 1 |
| | more_1y | > 1 |
| Feeding habits | collector_gat | Collector-Gatherer |
| | shredder | Shredder |
| | scraper | Scraper |
| | filter_feeder | Collector-Filterer |
| | predator | Predator |
| Locomotion | burrow | Burrower |
| | climber | Climber |
| | sprawler | Sprawler |
| | clinger | Clinger |
| | swimmer | Swimmer |
| Body flexibility (°) | flex_less_10 | <10 |
| | flex_10_45 | >10-45 |
| | flex_more_45 | >45 |
| Body form | streamlined | Streamlined |
| | flattened | Flattened |
| | cylindrical | Cylindrical |
| | spherical | Spherical |
| Relation to substrate | free_living | Free living |
| | silk_net_builder | Silk net builders |
| | case_builder | Case builder |

*Taxonomic richness, functional diversity and community specialization*

We assessed traditional metrics, such as taxonomic richness (rarefied) and Shannon index. In addition, we computed functional richness (FRic), which represents the volume in trait space occupied by a community as the smallest convex volume in the *n*-dimensional trait space, including all organisms in the community (Villéger et al., 2008). We also calculated functional diversity using the functional dispersion index (FDis) proposed by Laliberté and

Legendre (2010). FDis is the mean distance in multidimensional trait space of individual species to the centroid of all species weighted by their relative abundances (Laliberté and Legendre, 2010).

Finally, we assessed community specialization using the indices proposed by Mondy and Usseglio-Polatera (2014). For each taxon and each trait, we calculated a taxon specialization index (TSI). A community specialization index (CSI) was deduced for each trait and each site by averaging the scaled TSIs of taxa weighted by the respective log-transformed abundances (see Mondy and Usseglio-Polatera, 2014 for further details). We further computed a global specialization index by averaging each trait CSI.

After testing for normality of residuals and homoscedasticity, we used ANOVA to evaluate whether the above biological metrics were affected by disturbance. We used the *post hoc* Tukey test to identify differences among the categories when tests were significant ($P<0.05$).

*Trait response of EPT assemblages to human disturbance*

To assess the significance of associations between a combination of trait categories and environmental variables, we combined RLQ and fourth-corner analyses as recommended by Dray et al. (2014). This method involves performing correspondence analysis (COA) on the log-transformed abundance of EPT genera (66 sites and 73 EPT genera) to derive scores for sites and genera that have the maximal correlation (Dolédec et al., 1996). To reduce the number of variables (61 initial variables) involved in RLQ, principal components analysis (PCA) was conducted on each group of variables (i.e., land use and cover, habitat morphology, substrate, flow, riparian canopy cover, in-stream cover, and water quality), and we extracted the first four axes of each PCA. Axes significantly related to the IDI index (i.e., human disturbance) were then used as new environmental variables in the RLQ analysis. We tested the global significance of the relationship between EPT biological traits and these environmental variables using a Monte Carlo test (9,999 permutations). As suggested by Dray et al. (2014), we considered model 6, which combines two permutation tests to determine the overall significance of the relationship between trait categories and environmental variables. The first model tests the null hypothesis that “species assemblages are randomly attributed to sites, irrespective of the site characteristics” (rows of the abundance table; model 2). The second model tests the null hypothesis that “species are distributed irrespective of their traits” (columns of the abundance table; model 4). Finally, for a more detailed and specific interpretation of trait-environment associations, fourth-corner analysis aided the quantifying and testing of all possible bivariate correlations between each trait category or their combination and each environmental variable. In all tests, we applied a false discovery rate adjustment of probabilities to correct for multiple comparisons. Fourth-corner tests were then directly applied onto the RLQ axes.

All analyses were performed in the R environment (R Core Development Team, 2016) with the *vegan* (Oksanen, 2017), *FD* (Laliberté et al., 2014), and *ade4* (Chessel et al., 2004) packages. A schematic diagram with all methodological steps is presented in Fig. 3.

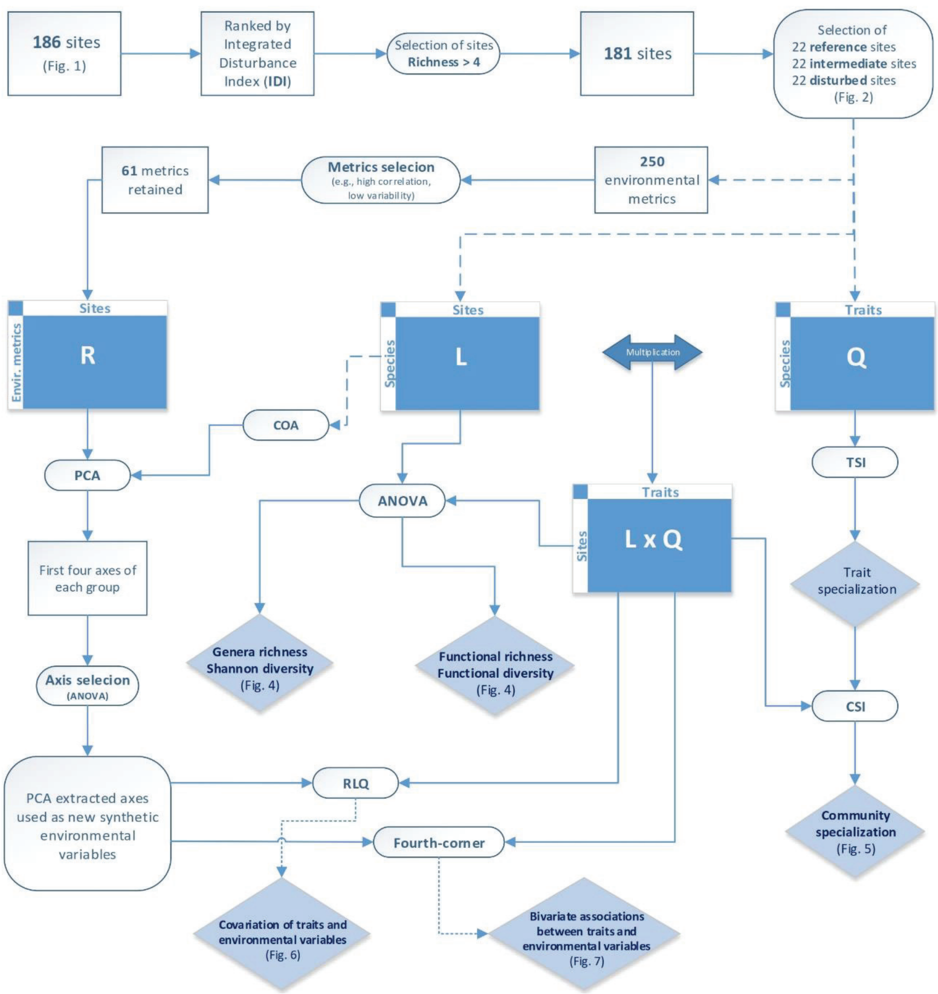


**Fig. 3.** Schematic diagram presenting the methodological design of site selection and statistical analyses used in this paper.

**Results**

*Taxonomic richness, functional diversity and community specialization*

EPT genus rarefied richness did not significantly differ among the levels of human disturbance ($F_{2,63}$ = 1.39, $P$ = 0.255, Fig. 4a). In contrast, functional richness was increased in the least-disturbed streams ($F_{2,63}$ = 9.13, $P$ < 0.001, Fig. 4b), which also supported EPT assemblages with higher Shannon ($F_{2,63}$ = 4.04, $P$ = 0.023, Fig. 4c) and functional diversities ($F_{2,63}$ = 10.6, $P$ < 0.001, Fig. 4d). In addition, EPT assemblages were overall more specialized in least disturbed compared with most disturbed streams (Fig. 5).

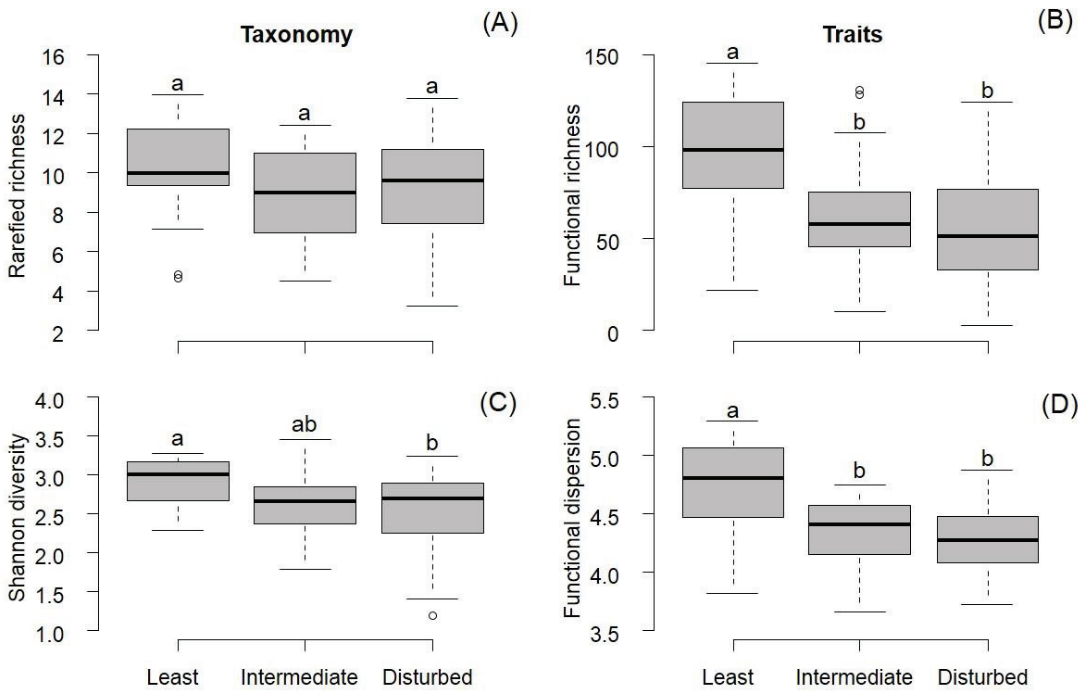


**Fig. 4.** Difference in (A) genus rarefied richness, (B) functional richness, (C) Shannon diversity, and (D) functional diversity (Functional dispersion) among the three categories of human pressure. Lines in boxes are medians, and box end are quantiles. Whiskers indicate maximum and minimum values, and circles represent outliers. Tukey *post hoc* tests were used for pairwise comparisons. Different letters indicate significant differences among the categories of disturbance.

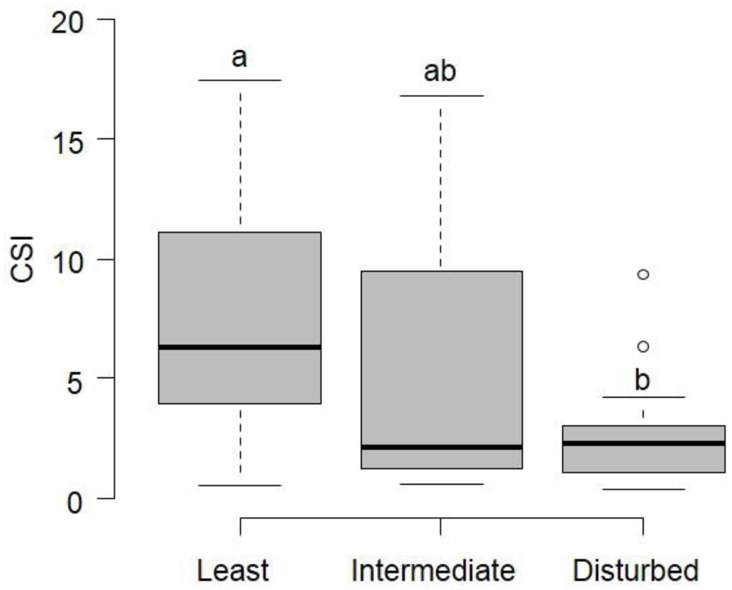


**Fig. 5.** Overall community specialization index (CSI) for EPT assemblages in each disturbance category. Lines in boxes are medians, and box end are quantiles. Whiskers indicate maximum and minimum values, and circles represent outliers. Tukey HSD *post hoc* tests were used for pairwise comparisons. Different letters indicate significant differences among the categories of human pressure.

*Trait response of EPT assemblages to human disturbance*

The global RLQ test revealed a significant relationship between genus abundance and environmental variables (model 2, *P*=0.001) as well as genus abundance and biological traits (model 4, *P*=0.045). We focused on the first RLQ axis, given that it explained most of the variability (i.e., 79.3% vs. 8.9% for the second axis; Fig. 6; Table 3) and strongly differentiated least from intermediately disturbed and disturbed streams (Fig. 6b). Environmental variables associated with least disturbed streams included increased mean herbaceous and woody ground-layer cover, higher mean herbaceous and woody mid-layer cover, reduced mean exposed soil (Cano_1 in Fig. 6a), higher percentage of grassy-wood and woodland, lower percentage of agriculture (LandUse_2), and higher sequence of flow types and mean velocity (Flow_ 4; see supplementary material Fig A1). Intermediate and disturbed streams on the positive side of the first RLQ axis exhibited increased conductivity, total dissolved solids, total nitrogen, total phosphorus (Quality_1 in Fig. 6a), percentage of boulders and cobbles, mean substrate diameter, and percentage of agriculture as well as reduced relative bed stability

(Subs_3), house density, and percentage of natural and parkland cover and highway distance (LandUse_1; see supplementary material Fig A1).

**Table 3.** Statistics obtained from multivariate analysis with (A) separate analyses demonstrating eigenvalues and percentages of variance that represented the first axis of each analysis, and (B) RLQ analysis demonstrating eigenvalues and percentage of total variance that accounted for the first RLQ axis, covariance and correlation, projected variance of the environment, abundance, trait tables onto the first RLQ axis, and associated percentage of variance compared with separate analyses along the same axis.

| | Axis 1 | |
|---|---|---|
| (A) Separate analysis | eigenvalue | % of variance |
| Environment (PCA) | 4.07 | 40.7 |
| Abundance (COA) | 0.27 | 10.1 |
| Trait (FCA) | 0.35 | 23.9 |
| (B) RLQ analysis | | |
| Eigenvalue | 0.03 | 78.9 |
| Covariance | 0.18 | |
| Correlation | 0.16 | |
| R/RLQ | 3.92 | 96.2 |
| L/RLQ | 0.16 | 30.9 |
| Q/RLQ | 0.30 | 88.1 |

Trichoptera, such as *Barypenthus, Marilia, Triplectides,* and *Oxyetira, Nectopsyche,* were associated with least disturbed streams, whereas Ephemeroptera genera mainly occurred in intermediate and disturbed streams (e.g., *Zelusia, Callibaetis, Waltzoyphius, Farrodes, Miroculis*) (Fig. 6c). Least disturbed sites had higher proportions of individuals with large body size (>10 mm) and low flexibility (<10°), with <1 reproductive cycle per year, building cases and climbing (Fig. 6d). Intermediate and disturbed sites had increased proportions of free-living and highly flexible (>45°) individuals with small body size (<3.5 mm) and streamlined bodies, reproducing more than once a year, and swimming (Fig. 6d).

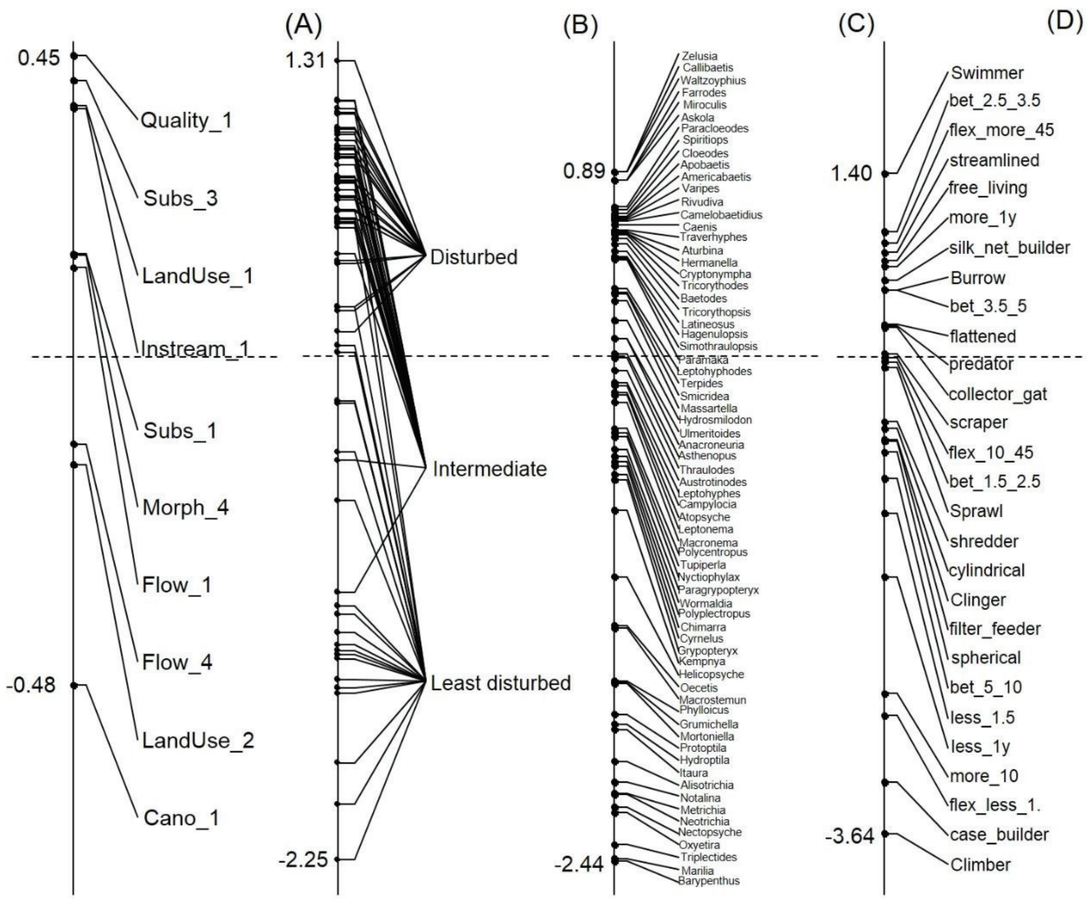


**Fig. 6.** RLQ analysis first axis scores demonstrating (A) environmental variable loadings (acronyms stand for the type of variable and the axis of the separate PCA), (B) distribution of site scores grouped by disturbance category, (C) EPT genus scores at the weighted average of sites where they are present, and (D) trait scores at the weighted average of their species. Dotted line is the axis center. Acronyms for traits and environmental variables are provided in Tables 1 and S1, respectively.

Fourth-corner analysis revealed significant correlations between several trait categories and environmental variables (Fig. 7). Higher riparian vegetation cover was positively associated with individuals with <1 reproductive cycle per year with a low flexibility of the body (<10°) and building case and negatively associated with swimming individuals with high flexibility of the body (>45°) and smaller body size (<3.5 mm). Lower water quality and bed stability and higher mean substrate diameter were positively associated with organisms with small body size (<3.5 mm), swimming and high body flexibility (Fig. 7). The first trait axis (AxcQ1) is significantly negatively correlated with canopy cover (Cano_1) and positively correlated with land use and cover (LandUse_1), substrate (Subst_3), in-stream cover (Instream_1) and water quality (Quality_1) (Table 4).

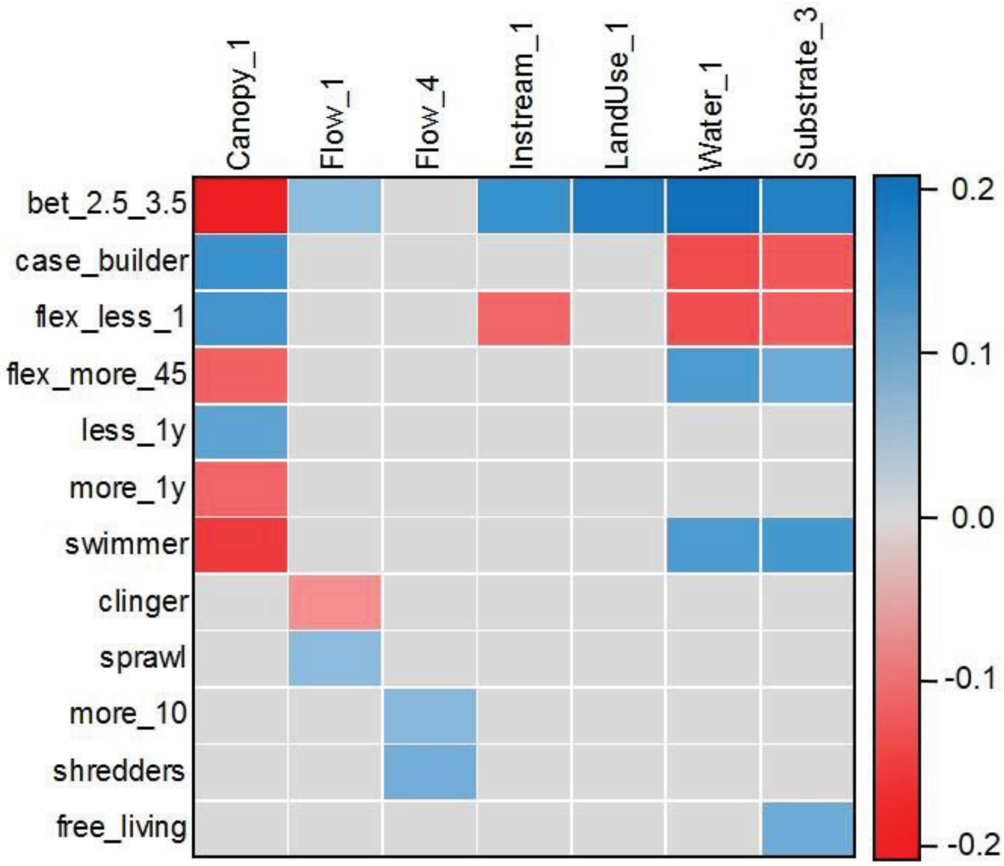


**Fig. 7.** Trait environment relationship resulting from fourth-corner analysis. Significant positive associations ($P < 0.05$) between the environmental variables and EPT trait categories are represented by blue cells, whereas significant negative associations are represented by red cells. The relative color tone indicates the strength of association. Non-significant associations are gray. The PCA axes of each group of environmental variables are noted along the *x*-axis. The trait categories are noted along the *y*-axis. Environmental variables and traits without any association are not presented for clarity. Codes for traits and environmental variables are provided in Table 1 and Table S1, respectively.

**Table 4.** Correlations between environmental variables (PCA loadings) and trait axis (AxcQ1). *P*-values in bold are significant relationships.

| Test | Std.Obs | *P* value |
|---|---|---|
| LandUse_1 / AxcQ1 | 0.1200 | **0.0188** |
| LandUse_2 / AxcQ1 | -0.0510 | 0.1329 |
| Morph_4 / AxcQ1 | 0.0488 | 0.1512 |
| Subs_1 / AxcQ1 | 0.0495 | 0.2697 |
| Subs_3 / AxcQ1 | 0.1319 | **0.0005** |
| Flow_1 / AxcQ1 | 0.0428 | 0.1511 |
| Flow_4 / AxcQ1 | -0.0411 | 0.1794 |
| Cano_1 / AxcQ1 | -0.1557 | **0.0003** |
| Instream_1 / AxcQ1 | 0.1188 | **0.0096** |
| Quality_1 / AxcQ1 | 0.1436 | **0.0035** |

**Discussion**

Our aim was to examine the reliability of the taxonomic and trait responses of EPT assemblages to overall human disturbance and to assess the effects of human disturbances on community specialization. Trait composition was more reliable than taxonomic composition in the assessment of the effects of human disturbances on the stream environment. In addition, the consequences of human disturbance included reducing the functional richness and diversity of EPT assemblages and increasing their homogenization.

*Taxonomic richness, functional diversity and community specialization*

In aquatic systems, land cover modification is a major driving force of biodiversity loss (Allan, 2004). The reduced functional richness and diversity observed in our study in the disturbed streams somewhat corroborate the habitat-filter hypothesis (Poff, 1997). This hypothesis postulates that only those taxa possessing a specific set of traits can pass the habitat filter and establish population in a given environment. Environmental filtering occurs when environmental pressures exceed the physiological limits of tolerance of individuals in local populations (Somero, 2010). In this context, human disturbances are additional environmental filters that can change the expected trait composition of assemblages observed in natural conditions (Floury et al., 2017). An increased functional richness implies that more niches are filled by taxa, whereas an increased functional dispersion indicates a more even distribution of a dissimilar trait. In our study, both functional richness and functional dispersion were increased in the least disturbed streams, suggesting that most of the functional trait space was occupied and that the species were well distributed in the functional space in least disturbed streams despite a lack of significant differences in taxonomic richness among the three categories of human disturbance.

In freshwater ecosystems, the replacement of habitat specialists by habitat generalists occurs as a response of assemblages to habitat degradation and land cover alteration (Petsch, 2016). In our study, EPT assemblages of disturbed streams were more functionally homogenous compared with least disturbed streams, suggesting a non-random effect of stress on homogenization (e.g., Mondy and Usseglio-Polatera, 2014; Smart et al., 2006). Specifically, we observed an increasing homogenization of traits providing resilience (e.g., body size, number of reproductive cycles per year) and resistance (e.g., relation to substrate, body form) capabilities to individuals in impacted sites. Given that homogenization causes a reduction in ecosystem resilience and resistance to environmental changes (Olden et al., 2004), we infer that most disturbed streams have lost the ability to resist future changes in a global human change scenario.

*Trait response of EPT assemblages to human disturbance*

Predictions of response to human disturbance made for 28 trait categories were fulfilled in 12 cases. Organisms with large body size and low body flexibility with <1 reproductive cycle per year, building case, and climbing characterized EPT assemblages of least-disturbed streams, whereas disturbed sites had increased proportions of organisms with small body size, streamlined, highly flexible, free-living, swimming, and reproducing more than once a year.

The first RLQ ordination axis accounted for a large fraction of the total variance explained, indicating the existence of a strong environmental gradient structuring the trait composition of EPT assemblages, which partially matched our *a priori* classification based on IDI (Fig. 2). Least disturbed streams were clearly separated from disturbed streams, whereas intermediate disturbed streams were generally superimposed with disturbed streams (Fig. 6). Riparian canopy cover and water quality were the main environmental drivers of the trait composition of EPT assemblages. In their natural state, wooded riparian zones are effective in preserving the ecological integrity and trophic dynamics of aquatic ecosystems (Ferreira et al., 2017). The replacement, reduction or removal of riparian vegetation cover generally leads to changes in physical habitat and hydromorphological and water quality characteristics (Ferreira et al., 2012; Pusey and Arthington, 2003), directly influencing the trophic dynamics and ecological integrity of aquatic ecosystems (e.g., Castro et al., 2016).

Body size and the number of reproductive cycles per year respond as expected *a priori* with the proportion of large body size individuals having <1 reproductive cycle per year occurring in the least disturbed streams, and small body size organisms with >1 reproductive cycles per year occurring in the disturbed streams. These latter trait categories confer resilience and/or resistance to disturbance, allowing for faster recolonization of disturbed environments as observed by other authors [Díaz et al., 2008; Dolédec et al., 2006; but see Ding et al., (2017) who recently observed the opposite effects in China headwater streams].

Organisms with small body size and low body flexibility increased in sites with reduced bed stability, heterogeneity and higher proportion of fine sediments. Heterogeneous substrates allow for more diverse benthic communities and provide refuge, whereas homogeneous substrates imply more exposition to physical disturbances, such as current velocity and shear stress (Beisel et al., 2000; Milesi et al., 2016). In addition, high flexibility provides advantages to taxa in sites with a high percentage of fine sediments, enabling the use of small interstices within the bed sediments (Gayraud and Philippe, 2001; Lamouroux et al., 2004, Descloux et al., 2014).

Small body size, high body flexibility and swimmers were also positively associated with low water quality related to wastewater (Stalter et al., 2013) and agricultural activities (Johnson et al., 1997). In our study, water quality correlated with land use intensity, especially with an increased percentage of agriculture and pasture areas and house density. We believe that the association of these traits is associated with the fact that water quality covaries with the substrate, which directly affects the trait composition of assemblages. However, conductivity, total dissolved solids and other water parameters may also causally affect invertebrate composition, acting as one of the environmental filters determining assemblage composition (Olson and Hawkins, 2017). For example, salinity and total dissolved solids can induce physiological stress in freshwater organisms adapted to low concentrations and could affect their fitness (Berger et al., 2017; Cañedo-Argüelles et al., 2013; Olson and Hawkins, 2017), eliminating some species and indirectly changing the trait composition of assemblages.

Functional feeding groups exhibited weak relationships with environmental variables. We did not identify the expected relationship between shredders and riparian cover or filter feeders and water quality. These results are associated with the great trophic plasticity and opportunistic feeding habits of Neotropical aquatic insects (Castro et al., 2016; Ceneviva-Bastos et al., 2017; Ferreira et al., 2015).

Identifying how human pressures modify the trait composition of assemblages can improve our predictive capability about patterns and processes in freshwater ecosystem and help the development of tools that complement traditional assessment for management actions and conservation initiatives (Jonsson et al., 2016; Pallottini et al., 2016). Our MTB approach has proven to improve our ability to evaluate the functional response of assemblages to human disturbance gradients. The RLQ and fourth-corner integrated analysis significantly discriminated streams with different levels of human disturbance. However, the lack of information about Neotropical invertebrate traits is one of the main limitations in using the trait approach. Nevertheless, few studies have established the foundation for building a database for Neotropical aquatic invertebrate species (Dedieu et al., 2015; Milesi et al., 2016; Reynaga and Santos, 2013; Tomanova and Usseglio-Polatera, 2007, Castro et al., in review). Gathering the maximum information possible and including more biological traits known to respond to specific human pressures is crucial to improve our understanding of the functioning of lotic ecosystems, providing tools for biomonitoring and conservation of Neotropical streams.

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**Table A.1.** Local, Catchment and Integrated Disturbance indexes to each sample site.

| Site | Categorie | IDI | LDI | CDI |
|---|---|---|---|---|
| Distur_01 | Disturbed | 0.7048 | 2.2735 | 161.5385 |
| Distur_02 | Disturbed | 0.7284 | 2.3565 | 166.6287 |
| Distur_03 | Disturbed | 0.7870 | 2.5466 | 180.0000 |
| Distur_04 | Disturbed | 0.7216 | 2.2579 | 168.8525 |
| Distur_05 | Disturbed | 0.6822 | 1.8940 | 170.1961 |
| Distur_06 | Disturbed | 0.6481 | 1.3340 | 177.1845 |
| Distur_07 | Disturbed | 0.7223 | 2.1064 | 176.0000 |
| Distur_08 | Disturbed | 0.7115 | 1.8335 | 182.9268 |
| Distur_09 | Disturbed | 0.6430 | 1.6445 | 165.7511 |
| Distur_10 | Disturbed | 0.6487 | 0.2045 | 194.2149 |
| Distur_11 | Disturbed | 0.6583 | 1.0005 | 188.1549 |
| Distur_12 | Disturbed | 0.6991 | 2.1970 | 163.1274 |
| Distur_13 | Disturbed | 0.7169 | 1.9244 | 181.4531 |
| Distur_14 | Disturbed | 0.7463 | 2.0761 | 186.0285 |
| Distur_15 | Disturbed | 0.6370 | 1.3340 | 173.5434 |
| Distur_16 | Disturbed | 0.7007 | 2.0383 | 170.9561 |
| Distur_17 | Disturbed | 0.6685 | 1.6667 | 173.8549 |
| Distur_18 | Disturbed | 0.7076 | 2.6445 | 141.0109 |
| Distur_19 | Disturbed | 0.6447 | 0.9928 | 184.0084 |
| Distur_20 | Disturbed | 0.6453 | 2.1289 | 145.4732 |
| Distur_21 | Disturbed | 0.7920 | 2.5761 | 180.4462 |
| Distur_22 | Disturbed | 0.7474 | 2.0909 | 185.8335 |
| Interm_01 | Intermediate | 0.2877 | 1.3409 | 31.2085 |
| Interm_02 | Intermediate | 0.3364 | 1.6521 | 18.9990 |
| Interm_03 | Intermediate | 0.4479 | 1.9705 | 63.8457 |
| Interm_04 | Intermediate | 0.2682 | 0.5608 | 73.0925 |
| Interm_05 | Intermediate | 0.4115 | 1.4621 | 86.8439 |
| Interm_06 | Intermediate | 0.3092 | 1.2123 | 57.5777 |
| Interm_07 | Intermediate | 0.6052 | 0.3032 | 180.6452 |
| Interm_08 | Intermediate | 0.5676 | 0.8565 | 162.3529 |
| Interm_09 | Intermediate | 0.5634 | 1.0380 | 157.1429 |
| Interm_10 | Intermediate | 0.5996 | 0.8337 | 172.7880 |
| Interm_11 | Intermediate | 0.5291 | 0.1364 | 158.5185 |
| Interm_12 | Intermediate | 0.5114 | 0.6670 | 148.1030 |
| Interm_13 | Intermediate | 0.4511 | 0.9547 | 122.6042 |
| Interm_14 | Intermediate | 0.5207 | 1.1290 | 140.7660 |
| Interm_15 | Intermediate | 0.5413 | 0.7880 | 155.3528 |
| Interm_16 | Intermediate | 0.4710 | 0.6670 | 135.5098 |
| Interm_17 | Intermediate | 0.4413 | 1.7274 | 82.3565 |
| Interm_18 | Intermediate | 0.5245 | 0.8488 | 148.8730 |
| Interm_19 | Intermediate | 0.4145 | 0.0000 | 124.3464 |
| Interm_20 | Intermediate | 0.4102 | 0.0000 | 123.0575 |
| Interm_21 | Intermediate | 0.3224 | 1.3896 | 49.0330 |
| Interm_22 | Intermediate | 0.3283 | 0.9449 | 80.5397 |
| Ref_01 | Least disturbed | 0.1739 | 0.1213 | 51.6676 |
| Ref_02 | Least disturbed | 0.0130 | 0.0000 | 3.8880 |
| Ref_03 | Least disturbed | 0.1331 | 0.0000 | 39.9275 |
| Ref_04 | Least disturbed | 0.1428 | 0.0000 | 42.8442 |
| Ref_05 | Least disturbed | 0.0423 | 0.0910 | 11.4647 |
| Ref_06 | Least disturbed | 0.1588 | 0.2727 | 44.7354 |
| Ref_07 | Least disturbed | 0.0404 | 0.1136 | 10.0203 |
| Ref_08 | Least disturbed | 0.0000 | 0.0000 | 0.0000 |
| Ref_09 | Least disturbed | 0.0997 | 0.0000 | 29.9221 |
| Ref_10 | Least disturbed | 0.0000 | 0.0000 | 0.0000 |

| Site | Categorie | IDI | LDI | CDI |
|---|---|---|---|---|
| Ref_11 | Least disturbed | 0.0000 | 0.0000 | 0.0000 |
| Ref_12 | Least disturbed | 0.1512 | 0.1250 | 44.7354 |
| Ref_13 | Least disturbed | 0.1797 | 0.6670 | 36.1362 |
| Ref_14 | Least disturbed | 0.0382 | 0.0000 | 11.4647 |
| Ref_15 | Least disturbed | 0.0000 | 0.0000 | 0.0000 |
| Ref_16 | Least disturbed | 0.0000 | 0.0000 | 0.0000 |
| Ref_17 | Least disturbed | 0.0000 | 0.0000 | 0.0000 |
| Ref_18 | Least disturbed | 0.0667 | 0.3335 | 0.0000 |
| Ref_19 | Least disturbed | 0.1217 | 0.3891 | 28.0517 |
| Ref_20 | Least disturbed | 0.0077 | 0.0000 | 2.3121 |
| Ref_21 | Least disturbed | 0.0397 | 0.0000 | 11.9122 |
| Ref_22 | Least disturbed | 0.1751 | 0.0000 | 52.5151 |

**Table A.2.** Environmental variables and their codes and definitions. Average values and standard deviation (in parentheses) are provided for each group of environment disturbance. Each disturbance category includes 22 streams.

| Variable groups and names | Variable code | Human pressure | | |
|---|---|---|---|---|
| | | Disturbed | Intermediate | Least disturbed |
| **Land use and cover** | | | | |
| % of Woodland savanna | Woodland | 3.076 (0.498) | 3.947 (1.327) | 3.044 (1.774) |
| % of Parkland savanna | Parkland | 0 (0) | 0.761 (1.019) | 2.535 (0.852) |
| % of Grassy-woody savanna | Grassy_Woody | 0.689 (0.736) | 1.089 (0.962) | 0.743 (1.144) |
| % of Palm swamp | Palm_swamp | 0.878 (1.095) | 0.842 (1.177) | 0.185 (0.601) |
| % of Pasture use | Pasture | 0.938 (0.995) | 1.982 (0.815) | 1.001 (1.067) |
| % of Agricultural use | Agriculture | 80.999 (11.925) | 43.356 (33.025) | 5.094 (7.784) |
| % of Eucalyptus forest | Eucaliptus | 0.068 (0.317) | 0.579 (0.899) | 0.2 (0.649) |
| % of Natural land use | Natural | 1.055 (0.157) | 1.399 (0.302) | 1.926 (0.086) |
| Distance to cities (km) | City_dist | 12.381 (5.224) | 16.732 (7.683) | 21.811 (6.841) |
| Distance to paved highways (km) | Highway_dist | 1.17 (0.421) | 1.438 (0.432) | 1.804 (0.659) |
| Density of homes in the basin (houses/km²) | House_density | 2.093 (0.985) | 1.251 (0.754) | 0.631 (0.77) |
| **Hydromorphology** | | | | |
| Mean thalweg depth (cm) | depth_T | 1.533 (0.184) | 1.496 (0.246) | 1.519 (0.233) |
| Mean wetted width (m) | width | 1.43 (0.214) | 1.553 (0.189) | 1.512 (0.243) |
| Mean bankfull width (m) | BKF_W | 1.658 (0.233) | 1.78 (0.163) | 1.761 (0.195) |
| Mean bankfull height (m) | BKF_H | -0.039 (0.191) | 0.036 (0.151) | 0.052 (0.21) |
| Mean width x mean depth (m²) | WXD | 1.962 (0.351) | 2.049 (0.378) | 2.031 (0.431) |
| Mean width/depth ratio (m/m) | WD_RAT | 0.897 (0.189) | 1.058 (0.224) | 0.994 (0.2) |
| Mean bank angle (degrees) | BKA | 1.648 (0.125) | 1.619 (0.152) | 1.606 (0.157) |
| Water surface gradient over reach (%) | SLOPE | 0.859 (0.418) | 0.493 (0.472) | 1.211 (0.528) |
| **Substrate** | | | | |
| Mean embeddedness (%) | EMBED | 0.638 (0.237) | 0.676 (0.285) | 0.412 (0.266) |
| % of bedrock (>4000 mm) | PCT_BDRK | 0.683 (1.07) | 0.935 (1.095) | 2.143 (0.806) |
| % of boulders (250 to 4000 mm) | PCT_BL | 1.175 (0.973) | 1.06 (0.956) | 1.313 (1.067) |
| % of cobble (64 to 250mm) | PCT_CB | 1.397 (0.897) | 1.341 (0.919) | 1.572 (0.83) |
| % of coarse gravel (16 to 64 mm) | PCT_GC | 1.129 (0.933) | 1.19 (0.974) | 1.424 (1.036) |
| % of fine gravel (2 to 16mm) | PCT_GF | 1.589 (0.953) | 1.648 (0.894) | 1.297 (1.025) |
| % of sand (0.6 to2 mm) | PCT_SA | 1.515 (0.935) | 2.082 (0.739) | 1.596 (0.958) |
| % of fines (<0.6 mm) | PCT_FN | 1.951 (0.933) | 1.803 (0.886) | 1.041 (1.087) |
| Total Organic matter (%) | PCT_ORG | 2.151 (0.379) | 1.754 (0.834) | 1.405 (0.924) |
| % of Wood | PCT_WD | 0.415 (0.589) | 0.49 (0.766) | 0.136 (0.443) |
| Log10 estimated geometric mean substrate diameter (mm) | LSUB_DMM | 0.302 (1.242) | 0.214 (1.183) | 0.14 (1.496) |
| Log10 - Relative Bed Stability (dimensionless: m/m)) | LRBS | -1.186 (1.321) | -0.641 (1.055) | 1.692 (1.15) |
| **Flow** | | | | |
| Flow - instantaneous discharge(m³/s) | FLOW_2 | 0.66 (0.173) | 0.565 (0.209) | 0.434 (0.243) |
| Velocity mean (m/s) | VEL | 0.749 (0.111) | 0.632 (0.213) | 0.503 (0.245) |
| Glides (%) | PCT_GL | 0.715 (0.357) | 0.801 (0.435) | 0.691 (0.474) |
| Percentage of rapids and riffles (%) | PCT_FAST | 0.497 (0.24) | 0.447 (0.306) | 0.54 (0.324) |
| Percentage of pools | PCT_POOL | 0.857 (1.124) | 0.736 (1.037) | 0.621 (1.067) |
| Sequence fasts, glides and pools (1= maximum Heterogenity, 0= maximum homogenity ) | SEQ_FLO_1 | 0.852 (0.309) | 0.587 (0.258) | 1.152 (0.395) |
| **Canopy cover** | | | | |
| Mean mid-channel canopy density (%) | CDENMID | 1.036 (0.25) | 0.933 (0.313) | 0.471 (0.331) |
| Mean canopy cover > 0.3m DBH | CL | 0.72 (0.552) | 0.882 (0.467) | 0.272 (0.461) |
| Mean canopy cover ≤ 0.3m DBH | CS | 3.816 (2.196) | 4.22 (1.647) | 2.884 (2.047) |
| Mean woody mid-layer cover | MW | 4.416 (2.058) | 5.325 (1.096) | 6.063 (2.106) |

| Variable groups and names | Variable code | Human pressure | | |
|---|---|---|---|---|
| | | Disturbed | Intermediate | Least disturbed |
| Mean herbaceous mid-layer cover | MH | 2.801 (2.024) | 4.435 (1.492) | 5.209 (2.736) |
| Mean woody ground-layer cover | GW | 1.023 (0.371) | 1.221 (0.353) | 1.569 (0.437) |
| Mean herbaceous ground-layer cover | GH | 3.632 (2.074) | 5 (1.767) | 7.609 (2.304) |
| Mean exposed soil | GB | 0.406 (0.178) | 0.384 (0.175) | 0.166 (0.234) |
| Mean riparian veg canopy cover | C | 4.785 (2.577) | 5.29 (2.125) | 3.172 (2.297) |
| **In-stream cover** | | | | |
| % of Areal cover filamentous algae | FC_ALG | 0.06 (0.193) | 0.33 (0.694) | 0.751 (0.88) |
| % of Areal cover aquatic macrophytes | FC_AQM | 0.411 (0.597) | 0.373 (0.587) | 1.098 (0.866) |
| % of Areal cover large woody debris | FC_LWD | 1.155 (0.829) | 1.208 (0.736) | 1.271 (0.912) |
| % of Areal cover brush | FC_BRS | 1.997 (0.438) | 1.651 (0.764) | 0.294 (0.67) |
| % of Areal cover live trees | FC_ROT | 4.122 (1.598) | 3.519 (1.415) | 3.909 (1.725) |
| % of Areal cover leaves bank | FC_LEB | 4.456 (2.435) | 4.62 (1.743) | 2.852 (2.454) |
| % of Areal cover undercut banks | FC_UCB | 2.161 (1.592) | 2.342 (1.345) | 2.69 (1.718) |
| % of Areal cover boulders | FC_RCK | 1.241 (1.052) | 1.298 (1.003) | 1.96 (0.683) |
| **Water quality** | | | | |
| pH | pH | 7.214 (0.673) | 7.431 (0.874) | 6.671 (1.042) |
| Turbidity (UNT) | TURB | 0.659 (0.279) | 0.71 (0.273) | 0.224 (0.602) |
| Condutivity(µS/cm) | COND | 1.456 (0.311) | 1.456 (0.576) | 0.735 (0.652) |
| TDS (mg/L) | TDS | 1.999 (0.745) | 2.218 (0.572) | 1.015 (0.987) |
| Water temperature (°C) | TEMP | 20.245 (1.813) | 19.05 (1.986) | 19.014 (1.321) |
| Total Nitrogen (mg/L) | NO3 | 3.233 (0.431) | 3.069 (0.547) | 2.485 (0.543) |
| Total Phosphorus (mg/L) | PHOS | 0.846 (0.575) | 0.901 (0.481) | 0.418 (0.422) |

**Table A.3.** Trait profiles (proportion) of 74 Neotropical genus of Ephemeroptera, Plecoptera and Trichoptera for 28 categories in 7 biological traits.

| | Body size | | | | | | Potencial number of cycles per year | | Feeding habits | | | | | Locomotion | | | | | Body flexibility | | | Body form | | | | Relation to substrate | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Genus | <1.5 | 1.5 - 2.5 | 2.5 - 3.5 | 3.5 - 5.0 | 5.0 - 10.0 | >10 | < ou = 1 | > 1 | Collector-Gatherer | Shredder | Scraper | Collector-Filterer | Predator | Burrower | Climber | Sprawler | Clinger | Swimmer | <10° | >10-45° | >45° | Streamlined | Flattened | Cylindrical | Spherical | Free living | Silk-net builder | Case builder |
| **Ephemeroptera** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Americabaetis* | 0.03 | 0.48 | 0.35 | 0.1 | 0.05 | 0 | 0 | 1 | 0.4 | 0 | 0.6 | 0 | 0 | 0 | 0 | 0.29 | 0.29 | 0.43 | 0 | 0.25 | 0.75 | 0.25 | 0 | 0.75 | 0 | 1 | 0 | 0 |
| *Apobaetis* | 0.07 | 0.48 | 0.38 | 0.07 | 0 | 0 | 0 | 1 | 0.17 | 0.33 | 0.5 | 0 | 0 | 0 | 0 | 0.29 | 0.29 | 0.43 | 0 | 0.25 | 0.75 | 0.4 | 0 | 0.6 | 0 | 1 | 0 | 0 |
| *Askola* | 0 | 0.21 | 0.42 | 0.21 | 0.17 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0.24 | 0 | 0.38 | 0.08 | 0.3 | 0 | 0.47 | 0.53 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |
| *Asthenopus* | 0 | 0 | 0.04 | 0.27 | 0.58 | 0.11 | 1 | 0 | 0.4 | 0 | 0.2 | 0.4 | 0 | 0.75 | 0 | 0.25 | 0 | 0 | 0 | 0.25 | 0.75 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Aturbina* | 0.01 | 0.35 | 0.34 | 0.28 | 0.03 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0.29 | 0.29 | 0.43 | 0 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| *Baetodes* | 0.37 | 0.56 | 0.08 | 0 | 0 | 0 | 0 | 1 | 0.5 | 0 | 0.5 | 0 | 0 | 0 | 0 | 0.29 | 0.29 | 0.43 | 0 | 0 | 1 | 0.25 | 0 | 0.75 | 0 | 1 | 0 | 0 |
| *Caenis* | 0.07 | 0.39 | 0.38 | 0.14 | 0.03 | 0 | 0 | 1 | 0.6 | 0 | 0.4 | 0 | 0 | 0.29 | 0 | 0.43 | 0.29 | 0 | 0 | 0.5 | 0.5 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| *Callibaetis* | 0 | 0.11 | 0.23 | 0.25 | 0.41 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0.4 | 0.6 | 0 | 0.25 | 0.75 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Camelobaetidius* | 0.06 | 0.13 | 0.31 | 0.18 | 0.32 | 0 | 0 | 1 | 0.5 | 0 | 0.5 | 0 | 0 | 0.13 | 0 | 0.25 | 0.25 | 0.38 | 0 | 0.33 | 0.67 | 0.4 | 0 | 0.6 | 0 | 1 | 0 | 0 |
| *Campsurus* | 0.02 | 0.08 | 0.12 | 0.15 | 0.54 | 0.09 | 1 | 0 | 0.67 | 0 | 0 | 0.33 | 0 | 0.75 | 0 | 0.25 | 0 | 0 | 0 | 0.25 | 0.75 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Campylocia* | 0 | 0 | 0 | 0.1 | 0.35 | 0.55 | 0.22 | 0.78 | 0.17 | 0.33 | 0 | 0.5 | 0 | 0.43 | 0 | 0.29 | 0.29 | 0 | 0 | 0.5 | 0.5 | 0.6 | 0 | 0.4 | 0 | 1 | 0 | 0 |
| *Cloeodes* | 0.02 | 0.47 | 0.33 | 0.16 | 0.02 | 0 | 0 | 1 | 0.4 | 0 | 0.6 | 0 | 0 | 0 | 0 | 0.43 | 0.29 | 0.29 | 0 | 0.25 | 0.75 | 0.4 | 0 | 0.6 | 0 | 1 | 0 | 0 |
| *Cryptonympha* | 0 | 0.31 | 0.38 | 0.31 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0.14 | 0 | 0.29 | 0.29 | 0.29 | 0 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| *Farrodes* | 0.06 | 0.44 | 0.3 | 0.16 | 0.03 | 0 | 0 | 1 | 0.5 | 0 | 0.5 | 0 | 0 | 0 | 0 | 0.29 | 0.29 | 0.43 | 0 | 0 | 1 | 0.25 | 0.75 | 0 | 0 | 0 | 1 | 0 |
| *Guajirolus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0.4 | 0 | 0.6 | 0 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| *Hagenulopsis* | 0.15 | 0.35 | 0.26 | 0.2 | 0.04 | 0 | 0.4 | 0.6 | 0.5 | 0 | 0.5 | 0 | 0 | 0.67 | 0 | 0.33 | 0 | 0 | 0 | 0.47 | 0.53 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |
| *Hermanella* | 0 | 0.27 | 0.18 | 0.36 | 0.18 | 0 | 0.4 | 0.6 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0.4 | 0 | 0.6 | 0 | 0.47 | 0.53 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |
| *Hexagenia* | 0 | 0.17 | 0 | 0.5 | 0.33 | 0 | 1 | 0 | 0.75 | 0 | 0 | 0.25 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0.5 | 0.5 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Hydrosmilodon* | 0.02 | 0.21 | 0.29 | 0.36 | 0.12 | 0 | 1 | 0 | 0.4 | 0 | 0.6 | 0 | 0 | 0.75 | 0 | 0.25 | 0 | 0 | 0 | 0.47 | 0.53 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |
| *Latineosus* | 0.12 | 0.45 | 0.14 | 0.19 | 0.1 | 0 | 0 | 1 | 0.6 | 0 | 0.4 | 0 | 0 | 0.4 | 0 | 0.6 | 0 | 0 | 0 | 0.5 | 0.5 | 0 | 0.5 | 0.5 | 0 | 1 | 0 | 0 |
| *Leptohyphes* | 0.22 | 0.42 | 0.24 | 0.09 | 0.03 | 0 | 1 | 0 | 0.5 | 0.17 | 0.33 | 0 | 0 | 0.29 | 0 | 0.43 | 0.29 | 0 | 0 | 0.5 | 0.5 | 0.17 | 0.5 | 0.33 | 0 | 1 | 0 | 0 |
| *Leptohyphodes* | 0 | 0 | 0.07 | 0.14 | 0.79 | 0 | 0 | 1 | 0.5 | 0.17 | 0.33 | 0 | 0 | 0.29 | 0 | 0.43 | 0.29 | 0 | 0 | 0.5 | 0.5 | 0.2 | 0.4 | 0.4 | 0 | 1 | 0 | 0 |
| *Massartella* | 0 | 0.09 | 0.06 | 0.21 | 0.42 | 0.23 | 0.4 | 0.6 | 0.41 | 0.04 | 0.54 | 0.01 | 0 | 0.24 | 0 | 0.38 | 0.08 | 0.3 | 0 | 0.47 | 0.53 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |
| *Miroculis* | 0.02 | 0.27 | 0.26 | 0.32 | 0.14 | 0 | 0 | 1 | 0.5 | 0 | 0.5 | 0 | 0 | 0 | 0 | 0.5 | 0 | 0.5 | 0 | 0.47 | 0.53 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |
| *Paracloeodes* | 0.02 | 0.38 | 0.35 | 0.24 | 0.01 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0.5 | 0.17 | 0.33 | 0 | 0.25 | 0.75 | 0.4 | 0 | 0.6 | 0 | 1 | 0 | 0 |
| *Paramaka* | 0 | 1 | 0 | 0 | 0 | 0 | 0.4 | 0.6 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0.6 | 0 | 0.4 | 0 | 0.47 | 0.53 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |
| *Rivudiva* | 0 | 0.13 | 0.39 | 0.48 | 0 | 0 | 0 | 1 | 0.5 | 0 | 0.5 | 0 | 0 | 0 | 0 | 0.5 | 0.17 | 0.33 | 0 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| *Simothraulopsis* | 0 | 0 | 0.11 | 0.33 | 0.56 | 0 | 0.4 | 0.6 | 0.4 | 0 | 0.6 | 0 | 0 | 0 | 0 | 0.5 | 0 | 0.5 | 0 | 0.47 | 0.53 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |
| *Spiritiops* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0.2 | 0.2 | 0.6 | 0 | 0 | 0 | 0 | 0 | 0.4 | 0.6 | 0 | 0.25 | 0.75 | 0.5 | 0 | 0.5 | 0 | 1 | 0 | 0 |
| *Terpides* | 0 | 0.09 | 0.16 | 0.28 | 0.47 | 0 | 0.4 | 0.6 | 0.38 | 0.38 | 0.25 | 0 | 0 | 0.43 | 0 | 0.29 | 0.14 | 0.14 | 0 | 0.67 | 0.33 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |
| *Thraulodes* | 0.05 | 0.33 | 0.31 | 0.18 | 0.12 | 0 | 1 | 0 | 0.43 | 0 | 0.43 | 0.14 | 0 | 0.33 | 0 | 0.22 | 0.33 | 0.11 | 0 | 0.75 | 0.25 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |
| *Traverhyphes* | 0.08 | 0.36 | 0.32 | 0.22 | 0.01 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0.29 | 0 | 0.43 | 0.29 | 0 | 0 | 0.5 | 0.5 | 0.2 | 0.4 | 0.4 | 0 | 1 | 0 | 0 |
| *Tricorythodes* | 0.11 | 0.28 | 0.39 | 0.2 | 0.03 | 0 | 0 | 1 | 0.75 | 0 | 0.25 | 0 | 0 | 0.29 | 0 | 0.43 | 0.29 | 0 | 0 | 0.5 | 0.5 | 0.2 | 0.4 | 0.4 | 0 | 1 | 0 | 0 |

| Genus | Body size | | | | | | Potencial number of cycles per year | | Feeding habits | | | | | Locomotion | | | | | Body flexibility | | | Body form | | | | Relation to substrate | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | <1.5 | 1.5 - 2.5 | 2.5 - 3.5 | 3.5 - 5.0 | 5.0 - 10.0 | >10 | < ou = 1 | > 1 | Collector-Gatherer | Shredder | Scraper | Collector-Filterer | Predator | Burrower | Climber | Sprawler | Clinger | Swimmer | <10° | >10-45° | >45° | Streamlined | Flattened | Cylindrical | Spherical | Free living | Silk-net builder | Case builder |
| *Tricorythopsis* | 0.19 | 0.77 | 0.04 | 0 | 0 | 0 | 0 | 1 | 0.75 | 0 | 0.25 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0.5 | 0.5 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |
| *Ulmeritoides* | 0.03 | 0.25 | 0.18 | 0.21 | 0.33 | 0.01 | 1 | 0 | 0.41 | 0.04 | 0.54 | 0.01 | 0 | 0.24 | 0 | 0.38 | 0.08 | 0.3 | 0 | 0.47 | 0.53 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |
| *Varipes* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0.5 | 0.17 | 0.33 | 0 | 0 | 0 | 0 | 0.17 | 0.33 | 0.5 | 0 | 0 | 1 | 0.25 | 0 | 0.75 | 0 | 1 | 0 | 0 |
| *Waltzoyphius* | 0.02 | 0.17 | 0.31 | 0.4 | 0.11 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0.43 | 0.29 | 0.29 | 0 | 0.25 | 0.75 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Zelusia* | 0.09 | 0.43 | 0.3 | 0.16 | 0.02 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0.38 | 0.25 | 0.38 | 0 | 0.25 | 0.75 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| **Plecoptera** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Anacroneuria* | 0.04 | 0.15 | 0.23 | 0.2 | 0.28 | 0.09 | 0 | 1 | 0.2 | 0.2 | 0 | 0 | 0.6 | 0 | 0 | 0.5 | 0.33 | 0.17 | 0.5 | 0.5 | 0 | 0.33 | 0.67 | 0 | 0 | 1 | 0 | 0 |
| *Grypopteryx* | 0.12 | 0.47 | 0.06 | 0.18 | 0.18 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0.25 | 0.5 | 0.25 | 0.5 | 0.5 | 0 | 0.78 | 0.22 | 0 | 0 | 1 | 0 | 0 |
| *Kempnya* | 0 | 0 | 0 | 0.2 | 0.6 | 0.2 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0.5 | 0.5 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Paragrypopteryx* | 0.12 | 0.74 | 0.14 | 0 | 0 | 0 | 1 | 0 | 0.33 | 0.33 | 0.33 | 0 | 0 | 0 | 0 | 0.25 | 0.5 | 0.25 | 0.5 | 0.5 | 0 | 0.78 | 0.22 | 0 | 0 | 1 | 0 | 0 |
| *Tupiperla* | 0.01 | 0.2 | 0.35 | 0.27 | 0.17 | 0 | 1 | 0 | 0.33 | 0.33 | 0.33 | 0 | 0 | 0 | 0 | 0.25 | 0.5 | 0.25 | 0.5 | 0.5 | 0 | 0.78 | 0.22 | 0 | 0 | 1 | 0 | 0 |
| **Trichoptera** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Alisotrichia* | 0.58 | 0.33 | 0 | 0 | 0.08 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0.75 | 0.25 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Anchitrichia* | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0.75 | 0.25 | 0 | 0.51 | 0.14 | 0.35 | 0 | 0 | 0 | 1 |
| *Atanatolia* | 0.14 | 0 | 0.14 | 0.43 | 0.29 | 0 | 1 | 0 | 0.07 | 0.36 | 0.32 | 0 | 0.25 | 0 | 0 | 1 | 0 | 0 | 0.75 | 0.25 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Atopsyche* | 0 | 0.17 | 0.24 | 0.28 | 0.29 | 0.03 | 1 | 0 | 0 | 0.25 | 0 | 0 | 0.75 | 0 | 0 | 0.43 | 0.43 | 0.14 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| *Austrotinodes* | 0 | 0.09 | 0.28 | 0.37 | 0.26 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0.5 | 0.5 |
| *Barypenthus* | 0 | 0 | 0 | 0.19 | 0.25 | 0.56 | 1 | 0 | 0.43 | 0.29 | 0.29 | 0 | 0 | 0 | 0 | 0.6 | 0.4 | 0 | 0.75 | 0.25 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Chimarra* | 0 | 0.11 | 0.19 | 0.23 | 0.37 | 0.1 | 1 | 0 | 0 | 0.25 | 0 | 0.75 | 0 | 0 | 0 | 0.5 | 0.5 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Cyrnelus* | 0 | 0.11 | 0.11 | 0.33 | 0.44 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Grumichella* | 0 | 0 | 0 | 1 | 3 | 0 | 0 | 0 | 2 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 3 | 1 | 0 | 0 | 0 | 3 | 0 | 0 | 1 | 3 |
| *Helicopsyche* | 0 | 0.18 | 0.43 | 0.33 | 0.08 | 0 | 0 | 1 | 0.6 | 0 | 0.4 | 0 | 0 | 0 | 0 | 0.5 | 0.5 | 0 | 0.75 | 0.25 | 0 | 0 | 0 | 0 | 1 | 0 | 0.25 | 0.75 |
| *Hydroptila* | 0.17 | 0.76 | 0.06 | 0.01 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0.5 | 0.5 | 0 | 0.75 | 0.25 | 0 | 0.67 | 0.33 | 0 | 0 | 0 | 0 | 1 |
| *Itaura* | 0.1 | 0.62 | 0.26 | 0.01 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0.25 | 0.75 | 0 | 0 | 0.4 | 0.6 |
| *Leptonema* | 0 | 0 | 0.12 | 0.05 | 0.13 | 0.7 | 0 | 1 | 0 | 0.2 | 0 | 0.6 | 0.2 | 0 | 0 | 0.33 | 0.5 | 0.17 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Macronema* | 0 | 0.12 | 0.05 | 0.16 | 0.26 | 0.41 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Macrostemun* | 0 | 0.08 | 0.08 | 0.15 | 0.23 | 0.46 | 1 | 0 | 0 | 0.13 | 0 | 0.73 | 0.13 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0.5 | 0.5 |
| *Marilia* | 0.01 | 0.09 | 0.23 | 0.27 | 0.39 | 0.01 | 1 | 0 | 0.38 | 0.13 | 0.38 | 0 | 0.13 | 0 | 0.5 | 0.5 | 0 | 0 | 0.75 | 0.25 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Metrichia* | 0.4 | 0.53 | 0.07 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0.75 | 0.25 | 0 | 0 | 0.5 | 0.5 | 0 | 0 | 0 | 1 |
| *Mortoniella* | 0.1 | 0.7 | 0.2 | 0 | 0 | 0 | 1 | 0 | 0.5 | 0 | 0.5 | 0 | 0 | 0 | 0 | 0.5 | 0.5 | 0 | 0.75 | 0.25 | 0 | 0 | 0.17 | 0.5 | 0.33 | 0 | 0.4 | 0.6 |
| *Nectopsyche* | 0.02 | 0.28 | 0.21 | 0.28 | 0.21 | 0 | 1 | 0 | 0.29 | 0.43 | 0.29 | 0 | 0 | 0 | 0.17 | 0.5 | 0.33 | 0 | 0.75 | 0.25 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Neotrichia* | 0.71 | 0.29 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0.5 | 0.5 | 0 | 0.75 | 0.25 | 0 | 0.4 | 0 | 0.6 | 0 | 0 | 0 | 1 |
| *Notalina* | 0.22 | 0.11 | 0.11 | 0.22 | 0.33 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0.75 | 0.25 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Nyctiophylax* | 0.11 | 0.67 | 0.11 | 0 | 0 | 0.11 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Oecetis* | 0.1 | 0.31 | 0.34 | 0.2 | 0.05 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0.5 | 0.5 | 0 | 0.75 | 0.25 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Oxyetira* | 0.05 | 0.66 | 0.24 | 0.06 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0.5 | 0.5 | 0 | 0 | 0.75 | 0.25 | 0 | 0.5 | 0 | 0.5 | 0 | 0 | 0 | 1 |

| Genus | Body size | | | | | | Potencial number of cycles per year | | Feeding habits | | | | | Locomotion | | | | | Body flexibility | | | Body form | | | | Relation to substrate | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | <1.5 | 1.5 - 2.5 | 2.5 - 3.5 | 3.5 - 5.0 | 5.0 - 10.0 | >10 | < ou = 1 | > 1 | Collector-Gatherer | Shredder | Scraper | Collector-Filterer | Predator | Burrower | Climber | Sprawler | Clinger | Swimmer | <10° | >10-45° | >45° | Streamlined | Flattened | Cylindrical | Spherical | Free living | Silk-net builder | Case builder |
| *Phylloicus* | 0.05 | 0.21 | 0.19 | 0.13 | 0.3 | 0.11 | 0 | 1 | 0.25 | 0.75 | 0 | 0 | 0 | 0 | 0 | 0.75 | 0.25 | 0 | 0.75 | 0.25 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Polycentropus* | 0 | 0.12 | 0.19 | 0.27 | 0.41 | 0.02 | 1 | 0 | 0 | 0.2 | 0 | 0.2 | 0.6 | 0 | 0 | 0.5 | 0.5 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Polyplectropus* | 0 | 0.01 | 0.09 | 0.24 | 0.66 | 0 | 1 | 0 | 0 | 0.07 | 0 | 0.4 | 0.53 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Protoptila* | 0.05 | 0.47 | 0.34 | 0.14 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0.5 | 0.5 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0.4 | 0.6 |
| *Smicridea* | 0 | 0.25 | 0.25 | 0.24 | 0.24 | 0 | 0 | 1 | 0 | 0.2 | 0 | 0.6 | 0.2 | 0 | 0 | 0.33 | 0.5 | 0.17 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Triplectides* | 0 | 0.07 | 0.07 | 0.1 | 0.5 | 0.27 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0.75 | 0.25 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Wormaldia* | 0 | 0.91 | 0 | 0.03 | 0.06 | 0 | 1 | 0 | 0 | 0 | 0.4 | 0.6 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |

**Table A.4.** Output of the significant values of the fourth-corner analysis. Codes for traits and environmental variables are provided in Tables 1 and S1, respectively.

| Test | Obs | Std.Obs | Pvalue | Pvalue.adj |
|---|---|---|---|---|
| Cano_1 / bet_2.5_3.5 | -0.178 | -4.180 | 0.001 | 0.070 |
| Cano_1 / case_builder | 0.126 | 2.970 | 0.003 | 0.105 |
| Cano_1 / flex_less_1. | 0.123 | 2.988 | 0.005 | 0.127 |
| Cano_1 / flex_more_45 | -0.107 | -2.661 | 0.008 | 0.147 |
| Cano_1 / less_1y | 0.103 | 2.519 | 0.006 | 0.129 |
| Cano_1 / more_1y | -0.103 | -2.519 | 0.006 | 0.129 |
| Cano_1 / Swimmer | -0.137 | -3.363 | 0.001 | 0.070 |
| Flow_1 / bet_2.5_3.5 | 0.070 | 2.391 | 0.015 | 0.183 |
| Flow_1 / Clinger | -0.072 | -2.324 | 0.020 | 0.215 |
| Flow_1 / Sprawl | 0.071 | 2.423 | 0.015 | 0.183 |
| Flow_4 / more_10 | 0.077 | 2.881 | 0.010 | 0.147 |
| Flow_4 / shredder | 0.088 | 3.249 | 0.002 | 0.093 |
| Instream_1 / bet_2.5_3.5 | 0.128 | 2.772 | 0.008 | 0.147 |
| Instream_1 / flex_less_1. | -0.102 | -2.316 | 0.021 | 0.218 |
| LandUse_1 / bet_2.5_3.5 | 0.154 | 3.173 | 0.004 | 0.112 |
| LandUse_2 / free_living | -0.074 | -2.192 | 0.019 | 0.213 |
| Quality_1 / bet_2.5_3.5 | 0.171 | 3.728 | 0.001 | 0.070 |
| Quality_1 / case_builder | -0.123 | -2.553 | 0.009 | 0.147 |
| Quality_1 / flex_less_1. | -0.121 | -2.589 | 0.009 | 0.147 |
| Quality_1 / flex_more_45 | 0.115 | 2.499 | 0.010 | 0.147 |
| Quality_1 / Swimmer | 0.115 | 2.492 | 0.018 | 0.210 |
| Subs_3 / bet_2.5_3.5 | 0.149 | 4.177 | 0.001 | 0.070 |
| Subs_3 / case_builder | -0.113 | -2.906 | 0.003 | 0.105 |
| Subs_3 / flex_less_1. | -0.108 | -2.859 | 0.004 | 0.112 |
| Subs_3 / flex_more_45 | 0.092 | 2.494 | 0.011 | 0.147 |
| Subs_3 / free_living | 0.091 | 2.475 | 0.011 | 0.147 |
| Subs_3 / Swimmer | 0.117 | 3.314 | 0.002 | 0.093 |

**Figure A.1.** PCAs of each group of environmental variables demonstrating the main variables discriminating each disturbance group (see acronyms in Table A1). We used those axes significantly related to the IDI index in the RLQ and fourth-corner analyses. In each graph, the black bars identify the selected axes.

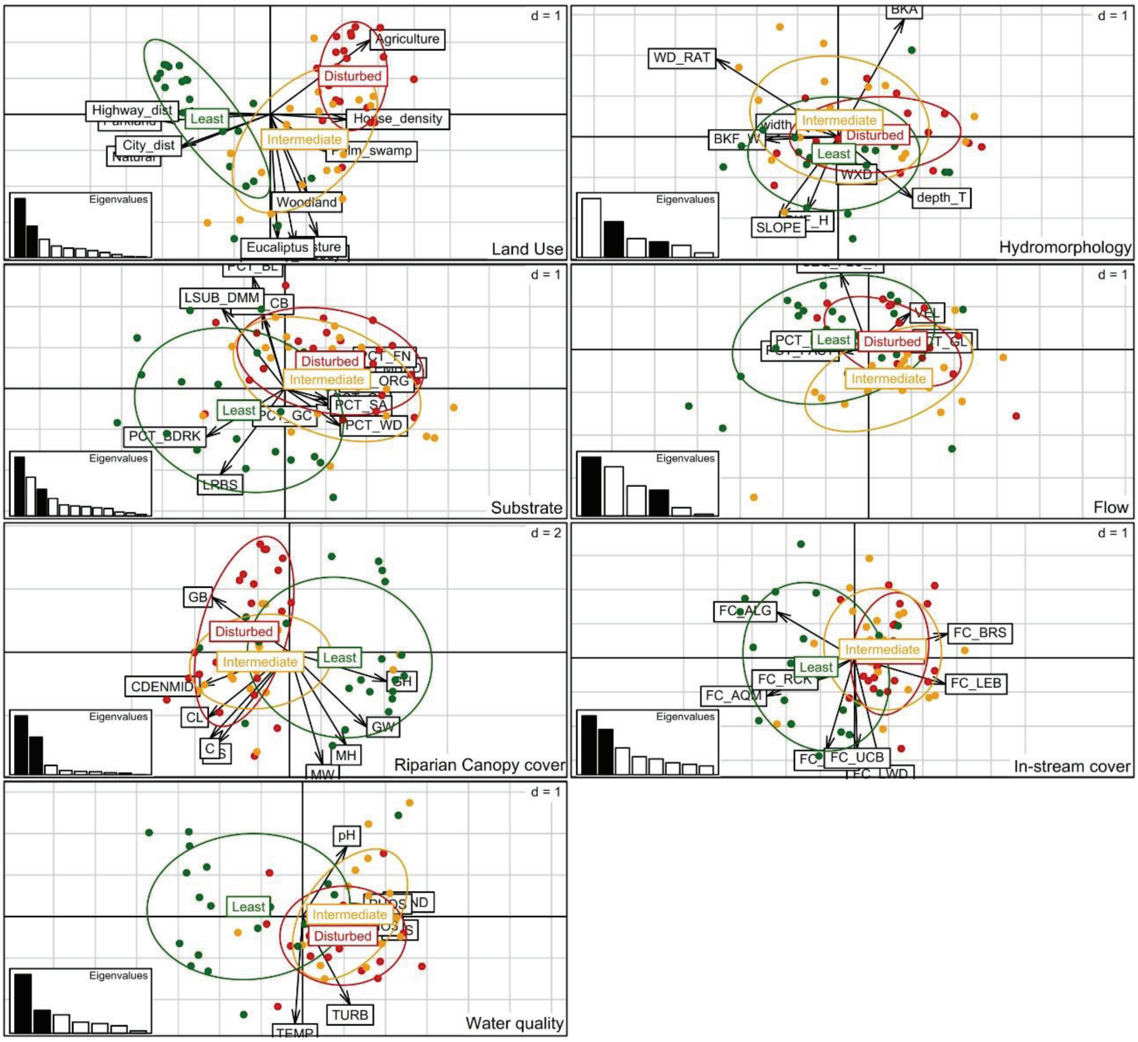
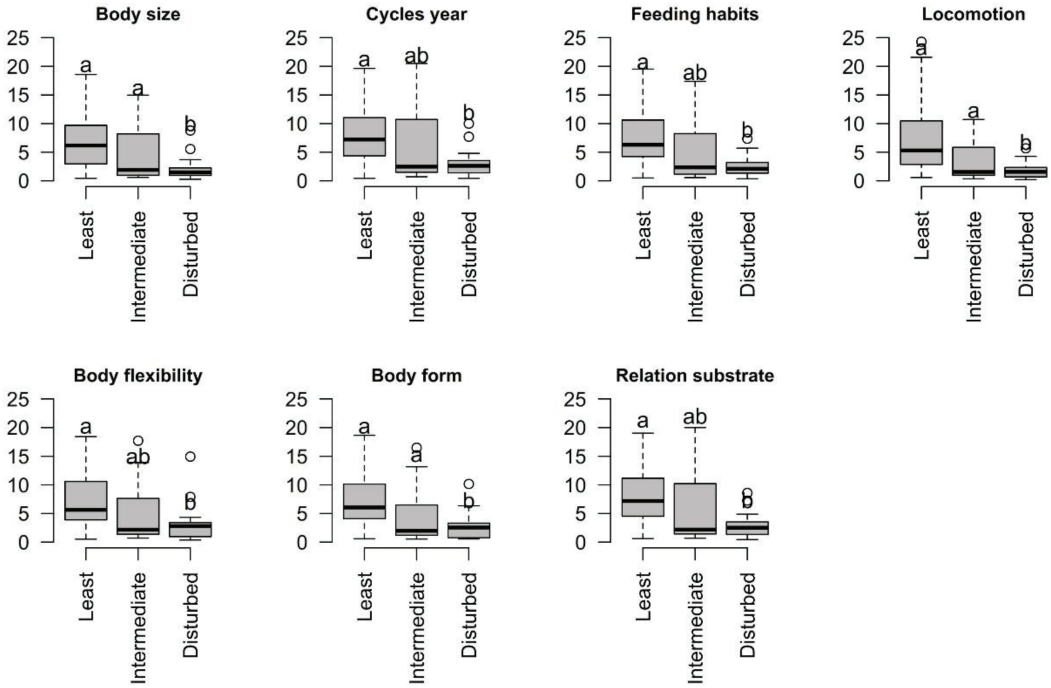


**Figure A.2.** Box-and-whisker plots demonstrating the values of the community specialization index (CSI) for each trait in each disturbance category. Lines in boxes are medians, and box end are quartiles. Whiskers indicate maximum and minimum values. Tukey *post hoc* tests were used for pairwise comparisons. Different letters indicate significant differences among the categories of disturbance.



# THESIS CONCLUSIONS

This thesis represents the first quantitative and multi-scale assessment of the impacts of human disturbances on the taxonomic and trait compositions of EPT assemblages and on their trophic relationships in neotropical savanna headwater streams. First, a specific EPT trait database was developed after a robust and extensive survey of exclusively neotropical literature and in which six traits were selected (among ~15 possible) that had sufficient and reliable information and were relevant to natural and human-type disturbances. Second, we identified which spatial scale and human disturbance variables drove the taxonomic and trait composition of the EPT assemblages in headwater streams. Finally, we observed that changes in land use led to homogenized communities in terms of their functional composition.

The main objective of this thesis was to investigate how the intensity of land use, through several pathways and spatial scales, influenced the functional structure of macroinvertebrate assemblages in neotropical savanna headwaters. The findings presented here demonstrate that an increase in land use intensity led to macroinvertebrate assemblages with more generalist feeding behaviors and a greater overlap of trophic niches (Chapter 1); that environmental variables at both the catchment and reach scales explain a significant amount of the variation in EPT taxa and trait composition, but that land use variables explain the greatest proportion of the trait composition differences between sites (Chapter 2); and that assemblages at the least-disturbed sites show a higher community specialization compared to disturbed sites (Chapter 3).

Losing biodiversity means losing ecosystem services (Cadotte et al. 2011, Cardinale et al. 2012). Therefore, assessing multiple components of the functional structure of assemblages using a trait-based approach is an appropriate alternative strategy because the diversity of ecological processes is likely closely related to the diversity of species’ functional traits (Diaz and Cabido 2001, Hooper et al. 2005, Reiss et al. 2009).

Overall, my thesis findings clearly corroborate that biodiversity should be assessed in a multifaceted framework that considers the functional elements of biotic assemblages. In addition, this study contributes to a better understanding of the structure and functioning of neotropical savanna headwater streams. This is especially important in the context of designing assessment tools to define priority conservation areas in the future and is important to the development of biological and functional integrity indices. Such approaches will aid the development of suitable management and conservation actions that will allow for evaluation of the impacts on biota of further degradation of ecological conditions, providing tools for the biomonitoring and conservation of tropical streams.

# FUTURE PERSPECTIVES

In a biodiversity hotspot and poorly studied region such as the neotropical Savanna, it is challenging to design research priorities with a scarcity of basic information on the distribution and natural history of macroinvertebrates. Further studies that expand our understanding of the effects of anthropogenic disturbances on neotropical savanna freshwater system integrity are greatly needed. Such studies would contribute to the improvement of knowledge about the natural history and traits of the other groups of macroinvertebrates that were not used in this thesis, as well as those in other aquatic systems, such as lagoons, reservoirs and large rivers. I particularly emphasize the development of the following approaches:

i. **Key functional traits:** some single functional traits (e.g., size or diet) may contribute to the provision of several ecosystem services while responding to specific drivers of change (e.g., land-use intensity). Specific functional traits that influence the provision of diverse ecosystem services and respond to drivers of change across a variety of systems and organisms might be considered “key functional traits” (Hevia et al. 2017). In fact, these are traits that, if affected by a given driver of change, will have major consequences on ecosystem functioning. Identifying those “key functional traits” and establishing relationships with the direct drivers of change and ecosystem services could lead to major advances in ecological research. For example, the ‘shredder’ feeding group acts as a response trait under the removal of riparian vegetation but also acts as an effect trait that contributes to the processing of leaf litter.

ii. **Linking functional traits to ecosystem process:** determining which functional traits have a significant impact on ecosystem processes remains an open empirical question in aquatic ecology. Controlled experiments asking specific questions should help to disentangle the key roles played by trait identity and diversity in mediating the effects of human disturbance on ecosystem functioning (Loreau et al. 2001, Hooper et al. 2005). The findings of this thesis may support this future approach by providing information about the main human impacts affecting trait compositions.

iii. **Functional Beta Diversity:** examining functional diversity at a variety of different scales—between species within a community (alpha diversity), between communities (i.e., beta diversity) and on a regional scale (i.e., gamma diversity)— may help to reveal changes in assembly processes along ecological gradients and how species' traits influence the ecological network structure.

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# THESIS APPENDICES

**Appendix 1:** Trait profiles (proportion) of 74 Neotropical genus of Ephemeroptera, Plecoptera and Trichoptera for 28 categories in 7 biological traits

**Appendix 2:** Tables with all raw environmental variables and their codes and definitions sampled in each site used in the thesis.

**Table 2.1.** Geophysical variables

**Table 2.2.** Land use variables

**Table 2.3.** Hydromorphological variables

**Table 2.4.** Substrate variables.

**Table 2.5.** Flow variables.

**Table 2.6.** Vegetation canopy cover variables.

**Table 2.7.** In-stream cover variables.

**Table 2.8.** Water quality variables.

**Table 2.9.** Index of Disturbance Integrated (Ligeiro et al. 2013) to each sampled site.

**Appendix 3:** Table with the abundance of Ephemeroptera, Plecoptera and Trichoptera in each sample site.

**Appendix 4:** Table with the abundance, count and average body size of each taxon measured in each sample site.

**Appendix 5:** Geographic coordinates of each sampled site.

Note: Appendices are available in the PDF version.

**Appendix 1:** Trait profiles (proportion) of 74 Neotropical genus of Ephemeroptera, Plecoptera and Trichoptera for 28 categories in 7 biological traits.

| Genus | Body size | | | | | | Potencial number of cycles per year | | Feeding habits | | | | | Locomotion | | | | | Body flexibility | | | Body form | | | | Relation to substrate | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | <1.5 | 1.5 - 2.5 | 2.5 - 3.5 | 3.5 - 5.0 | 5.0 - 10.0 | >10 | < ou = 1 | > 1 | Collector-Gatherer | Shredder | Scraper | Collector-Filterer | Predator | Burrower | Climber | Sprawler | Clinger | Swimmer | <10° | >10-45° | >45° | Streamlined | Flattened | Cylindrical | Spherical | Free living | Silk-net builder | Case builder |
| **Ephemeroptera** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Americabaetis* | 0.03 | 0.48 | 0.35 | 0.1 | 0.05 | 0 | 0 | 1 | 0.4 | 0 | 0.6 | 0 | 0 | 0 | 0 | 0.29 | 0.29 | 0.43 | 0 | 0.25 | 0.75 | 0.25 | 0 | 0.75 | 0 | 1 | 0 | 0 |
| *Apobaetis* | 0.07 | 0.48 | 0.38 | 0.07 | 0 | 0 | 0 | 1 | 0.17 | 0.33 | 0.5 | 0 | 0 | 0 | 0 | 0.29 | 0.29 | 0.43 | 0 | 0.25 | 0.75 | 0.4 | 0 | 0.6 | 0 | 1 | 0 | 0 |
| *Askola* | 0 | 0.21 | 0.42 | 0.21 | 0.17 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0.24 | 0 | 0.38 | 0.08 | 0.3 | 0 | 0.47 | 0.53 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |
| *Asthenopus* | 0 | 0 | 0.04 | 0.27 | 0.58 | 0.11 | 1 | 0 | 0.4 | 0 | 0.2 | 0.4 | 0 | 0.75 | 0 | 0.25 | 0 | 0 | 0 | 0.25 | 0.75 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Aturbina* | 0.01 | 0.35 | 0.34 | 0.28 | 0.03 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0.29 | 0.29 | 0.43 | 0 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| *Baetodes* | 0.37 | 0.56 | 0.08 | 0 | 0 | 0 | 0 | 1 | 0.5 | 0 | 0.5 | 0 | 0 | 0 | 0 | 0.29 | 0.29 | 0.43 | 0 | 0 | 1 | 0.25 | 0 | 0.75 | 0 | 1 | 0 | 0 |
| *Caenis* | 0.07 | 0.39 | 0.38 | 0.14 | 0.03 | 0 | 0 | 1 | 0.6 | 0 | 0.4 | 0 | 0 | 0.29 | 0 | 0.43 | 0.29 | 0 | 0 | 0.5 | 0.5 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| *Callibaetis* | 0 | 0.11 | 0.23 | 0.25 | 0.41 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0.4 | 0.6 | 0 | 0.25 | 0.75 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Camelobaetidius* | 0.06 | 0.13 | 0.31 | 0.18 | 0.32 | 0 | 0 | 1 | 0.5 | 0 | 0.5 | 0 | 0 | 0.13 | 0 | 0.25 | 0.25 | 0.38 | 0 | 0.33 | 0.67 | 0.4 | 0 | 0.6 | 0 | 1 | 0 | 0 |
| *Campsurus* | 0.02 | 0.08 | 0.12 | 0.15 | 0.54 | 0.09 | 1 | 0 | 0.67 | 0 | 0 | 0.33 | 0 | 0.75 | 0 | 0.25 | 0 | 0 | 0 | 0.25 | 0.75 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Campylocia* | 0 | 0 | 0 | 0.1 | 0.35 | 0.55 | 0.22 | 0.78 | 0.17 | 0.33 | 0 | 0.5 | 0 | 0.43 | 0 | 0.29 | 0.29 | 0 | 0 | 0.5 | 0.5 | 0.6 | 0 | 0.4 | 0 | 1 | 0 | 0 |
| *Cloeodes* | 0.02 | 0.47 | 0.33 | 0.16 | 0.02 | 0 | 0 | 1 | 0.4 | 0 | 0.6 | 0 | 0 | 0 | 0 | 0.43 | 0.29 | 0.29 | 0 | 0.25 | 0.75 | 0.4 | 0 | 0.6 | 0 | 1 | 0 | 0 |
| *Cryptonympha* | 0 | 0.31 | 0.38 | 0.31 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0.14 | 0 | 0.29 | 0.29 | 0.29 | 0 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| *Farrodes* | 0.06 | 0.44 | 0.3 | 0.16 | 0.03 | 0 | 0 | 1 | 0.5 | 0 | 0.5 | 0 | 0 | 0 | 0 | 0.29 | 0.29 | 0.43 | 0 | 0 | 1 | 0.25 | 0.75 | 0 | 0 | 0 | 1 | 0 |
| *Guajirolus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0.4 | 0 | 0.6 | 0 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| *Hagenulopsis* | 0.15 | 0.35 | 0.26 | 0.2 | 0.04 | 0 | 0.4 | 0.6 | 0.5 | 0 | 0.5 | 0 | 0 | 0.67 | 0 | 0.33 | 0 | 0 | 0 | 0.47 | 0.53 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |
| *Hermanella* | 0 | 0.27 | 0.18 | 0.36 | 0.18 | 0 | 0.4 | 0.6 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0.4 | 0 | 0.6 | 0 | 0.47 | 0.53 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |
| *Hexagenia* | 0 | 0.17 | 0 | 0.5 | 0.33 | 0 | 1 | 0 | 0.75 | 0 | 0 | 0.25 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0.5 | 0.5 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Hydrosmilodon* | 0.02 | 0.21 | 0.29 | 0.36 | 0.12 | 0 | 1 | 0 | 0.4 | 0 | 0.6 | 0 | 0 | 0.75 | 0 | 0.25 | 0 | 0 | 0 | 0.47 | 0.53 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |
| *Latineosus* | 0.12 | 0.45 | 0.14 | 0.19 | 0.1 | 0 | 0 | 1 | 0.6 | 0 | 0.4 | 0 | 0 | 0.4 | 0 | 0.6 | 0 | 0 | 0 | 0.5 | 0.5 | 0 | 0.5 | 0.5 | 0 | 1 | 0 | 0 |
| *Leptohyphes* | 0.22 | 0.42 | 0.24 | 0.09 | 0.03 | 0 | 1 | 0 | 0.5 | 0.17 | 0.33 | 0 | 0 | 0.29 | 0 | 0.43 | 0.29 | 0 | 0 | 0.5 | 0.5 | 0.17 | 0.5 | 0.33 | 0 | 1 | 0 | 0 |
| *Leptohyphodes* | 0 | 0 | 0.07 | 0.14 | 0.79 | 0 | 0 | 1 | 0.5 | 0.17 | 0.33 | 0 | 0 | 0.29 | 0 | 0.43 | 0.29 | 0 | 0 | 0.5 | 0.5 | 0.2 | 0.4 | 0.4 | 0 | 1 | 0 | 0 |
| *Massartella* | 0 | 0.09 | 0.06 | 0.21 | 0.42 | 0.23 | 0.4 | 0.6 | 0.41 | 0.04 | 0.54 | 0.01 | 0 | 0.24 | 0 | 0.38 | 0.08 | 0.3 | 0 | 0.47 | 0.53 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |
| *Miroculis* | 0.02 | 0.27 | 0.26 | 0.32 | 0.14 | 0 | 0 | 1 | 0.5 | 0 | 0.5 | 0 | 0 | 0 | 0 | 0.5 | 0 | 0.5 | 0 | 0.47 | 0.53 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |
| *Paracloeodes* | 0.02 | 0.38 | 0.35 | 0.24 | 0.01 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0.5 | 0.17 | 0.33 | 0 | 0.25 | 0.75 | 0.4 | 0 | 0.6 | 0 | 1 | 0 | 0 |
| *Paramaka* | 0 | 1 | 0 | 0 | 0 | 0 | 0.4 | 0.6 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0.6 | 0 | 0.4 | 0 | 0.47 | 0.53 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |
| *Rivudiva* | 0 | 0.13 | 0.39 | 0.48 | 0 | 0 | 0 | 1 | 0.5 | 0 | 0.5 | 0 | 0 | 0 | 0 | 0.5 | 0.17 | 0.33 | 0 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| *Simothraulopsis* | 0 | 0 | 0.11 | 0.33 | 0.56 | 0 | 0.4 | 0.6 | 0.4 | 0 | 0.6 | 0 | 0 | 0 | 0 | 0.5 | 0 | 0.5 | 0 | 0.47 | 0.53 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |
| *Spiritiops* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0.2 | 0.2 | 0.6 | 0 | 0 | 0 | 0 | 0 | 0.4 | 0.6 | 0 | 0.25 | 0.75 | 0.5 | 0 | 0.5 | 0 | 1 | 0 | 0 |
| *Terpides* | 0 | 0.09 | 0.16 | 0.28 | 0.47 | 0 | 0.4 | 0.6 | 0.38 | 0.38 | 0.25 | 0 | 0 | 0.43 | 0 | 0.29 | 0.14 | 0.14 | 0 | 0.67 | 0.33 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |
| *Thraulodes* | 0.05 | 0.33 | 0.31 | 0.18 | 0.12 | 0 | 1 | 0 | 0.43 | 0 | 0.43 | 0.14 | 0 | 0.33 | 0 | 0.22 | 0.33 | 0.11 | 0 | 0.75 | 0.25 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |

| Genus | Body size | | | | | | Potencial number of cycles per year | | Feeding habits | | | | | Locomotion | | | | | Body flexibility | | | Body form | | | | Relation to substrate | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | <1.5 | 1.5 - 2.5 | 2.5 - 3.5 | 3.5 - 5.0 | 5.0 - 10.0 | >10 | < ou = 1 | > 1 | Collector-Gatherer | Shredder | Scraper | Collector-Filterer | Predator | Burrower | Climber | Sprawler | Clinger | Swimmer | <10° | >10-45° | >45° | Streamlined | Flattened | Cylindrical | Spherical | Free living | Silk-net builder | Case builder |
| *Traverhyphes* | 0.08 | 0.36 | 0.32 | 0.22 | 0.01 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0.29 | 0 | 0.43 | 0.29 | 0 | 0 | 0.5 | 0.5 | 0.2 | 0.4 | 0.4 | 0 | 1 | 0 | 0 |
| *Tricorythodes* | 0.11 | 0.28 | 0.39 | 0.2 | 0.03 | 0 | 0 | 1 | 0.75 | 0 | 0.25 | 0 | 0 | 0.29 | 0 | 0.43 | 0.29 | 0 | 0 | 0.5 | 0.5 | 0.2 | 0.4 | 0.4 | 0 | 1 | 0 | 0 |
| *Tricorythopsis* | 0.19 | 0.77 | 0.04 | 0 | 0 | 0 | 0 | 1 | 0.75 | 0 | 0.25 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0.5 | 0.5 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |
| *Ulmeritoides* | 0.03 | 0.25 | 0.18 | 0.21 | 0.33 | 0.01 | 1 | 0 | 0.41 | 0.04 | 0.54 | 0.01 | 0 | 0.24 | 0 | 0.38 | 0.08 | 0.3 | 0 | 0.47 | 0.53 | 0.25 | 0.75 | 0 | 0 | 1 | 0 | 0 |
| *Varipes* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0.5 | 0.17 | 0.33 | 0 | 0 | 0 | 0 | 0.17 | 0.33 | 0.5 | 0 | 0 | 1 | 0.25 | 0 | 0.75 | 0 | 1 | 0 | 0 |
| *Waltzoyphius* | 0.02 | 0.17 | 0.31 | 0.4 | 0.11 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0.43 | 0.29 | 0.29 | 0 | 0.25 | 0.75 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Zelusia* | 0.09 | 0.43 | 0.3 | 0.16 | 0.02 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0.38 | 0.25 | 0.38 | 0 | 0.25 | 0.75 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| **Plecoptera** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Anacroneuria* | 0.04 | 0.15 | 0.23 | 0.2 | 0.28 | 0.09 | 0 | 1 | 0.2 | 0.2 | 0 | 0 | 0.6 | 0 | 0 | 0.5 | 0.33 | 0.17 | 0.5 | 0.5 | 0 | 0.33 | 0.67 | 0 | 0 | 1 | 0 | 0 |
| *Grypopteryx* | 0.12 | 0.47 | 0.06 | 0.18 | 0.18 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0.25 | 0.5 | 0.25 | 0.5 | 0.5 | 0 | 0.78 | 0.22 | 0 | 0 | 1 | 0 | 0 |
| *Kempnya* | 0 | 0 | 0 | 0.2 | 0.6 | 0.2 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0.5 | 0.5 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Paragrypopteryx* | 0.12 | 0.74 | 0.14 | 0 | 0 | 0 | 1 | 0 | 0.33 | 0.33 | 0.33 | 0 | 0 | 0 | 0 | 0.25 | 0.5 | 0.25 | 0.5 | 0.5 | 0 | 0.78 | 0.22 | 0 | 0 | 1 | 0 | 0 |
| *Tupiperla* | 0.01 | 0.2 | 0.35 | 0.27 | 0.17 | 0 | 1 | 0 | 0.33 | 0.33 | 0.33 | 0 | 0 | 0 | 0 | 0.25 | 0.5 | 0.25 | 0.5 | 0.5 | 0 | 0.78 | 0.22 | 0 | 0 | 1 | 0 | 0 |
| **Trichoptera** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *Alisotrichia* | 0.58 | 0.33 | 0 | 0 | 0.08 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0.75 | 0.25 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Anchitrichia* | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0.75 | 0.25 | 0 | 0.51 | 0.14 | 0.35 | 0 | 0 | 0 | 1 |
| *Atanatolia* | 0.14 | 0 | 0.14 | 0.43 | 0.29 | 0 | 1 | 0 | 0.07 | 0.36 | 0.32 | 0 | 0.25 | 0 | 0 | 1 | 0 | 0 | 0.75 | 0.25 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Atopsyche* | 0 | 0.17 | 0.24 | 0.28 | 0.29 | 0.03 | 1 | 0 | 0 | 0.25 | 0 | 0 | 0.75 | 0 | 0 | 0.43 | 0.43 | 0.14 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| *Austrotinodes* | 0 | 0.09 | 0.28 | 0.37 | 0.26 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0.5 | 0.5 |
| *Barypenthus* | 0 | 0 | 0 | 0.19 | 0.25 | 0.56 | 1 | 0 | 0.43 | 0.29 | 0.29 | 0 | 0 | 0 | 0 | 0.6 | 0.4 | 0 | 0.75 | 0.25 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Chimarra* | 0 | 0.11 | 0.19 | 0.23 | 0.37 | 0.1 | 1 | 0 | 0 | 0.25 | 0 | 0.75 | 0 | 0 | 0 | 0.5 | 0.5 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Cyrnelus* | 0 | 0.11 | 0.11 | 0.33 | 0.44 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Grumichella* | 0 | 0 | 0 | 1 | 3 | 0 | 0 | 0 | 2 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 3 | 1 | 0 | 0 | 0 | 3 | 0 | 0 | 1 | 3 |
| *Helicopsyche* | 0 | 0.18 | 0.43 | 0.33 | 0.08 | 0 | 0 | 1 | 0.6 | 0 | 0.4 | 0 | 0 | 0 | 0 | 0.5 | 0.5 | 0 | 0.75 | 0.25 | 0 | 0 | 0 | 0 | 1 | 0 | 0.25 | 0.75 |
| *Hydroptila* | 0.17 | 0.76 | 0.06 | 0.01 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0.5 | 0.5 | 0 | 0.75 | 0.25 | 0 | 0.67 | 0.33 | 0 | 0 | 0 | 0 | 1 |
| *Itaura* | 0.1 | 0.62 | 0.26 | 0.01 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0.25 | 0.75 | 0 | 0 | 0.4 | 0.6 |
| *Leptonema* | 0 | 0 | 0.12 | 0.05 | 0.13 | 0.7 | 0 | 1 | 0 | 0.2 | 0 | 0.6 | 0.2 | 0 | 0 | 0.33 | 0.5 | 0.17 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Macronema* | 0 | 0.12 | 0.05 | 0.16 | 0.26 | 0.41 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Macrostemun* | 0 | 0.08 | 0.08 | 0.15 | 0.23 | 0.46 | 1 | 0 | 0 | 0.13 | 0 | 0.73 | 0.13 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0.5 | 0.5 |
| *Marilia* | 0.01 | 0.09 | 0.23 | 0.27 | 0.39 | 0.01 | 1 | 0 | 0.38 | 0.13 | 0.38 | 0 | 0.13 | 0 | 0.5 | 0.5 | 0 | 0 | 0.75 | 0.25 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Metrichia* | 0.4 | 0.53 | 0.07 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0.75 | 0.25 | 0 | 0 | 0.5 | 0.5 | 0 | 0 | 0 | 1 |
| *Mortoniella* | 0.1 | 0.7 | 0.2 | 0 | 0 | 0 | 1 | 0 | 0.5 | 0 | 0.5 | 0 | 0 | 0 | 0 | 0.5 | 0.5 | 0 | 0.75 | 0.25 | 0 | 0 | 0.17 | 0.5 | 0.33 | 0 | 0.4 | 0.6 |
| *Nectopsyche* | 0.02 | 0.28 | 0.21 | 0.28 | 0.21 | 0 | 1 | 0 | 0.29 | 0.43 | 0.29 | 0 | 0 | 0 | 0.17 | 0.5 | 0.33 | 0 | 0.75 | 0.25 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Neotrichia* | 0.71 | 0.29 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0.5 | 0.5 | 0 | 0.75 | 0.25 | 0 | 0.4 | 0 | 0.6 | 0 | 0 | 0 | 1 |

| Genus | Body size | | | | | | Potencial number of cycles per year | | Feeding habits | | | | | Locomotion | | | | | Body flexibility | | | Body form | | | | Relation to substrate | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | <1.5 | 1.5 - 2.5 | 2.5 - 3.5 | 3.5 - 5.0 | 5.0 - 10.0 | >10 | < ou = 1 | > 1 | Collector-Gatherer | Shredder | Scraper | Collector-Filterer | Predator | Burrower | Climber | Sprawler | Clinger | Swimmer | <10° | >10-45° | >45° | Streamlined | Flattened | Cylindrical | Spherical | Free living | Silk-net builder | Case builder |
| *Notalina* | 0.22 | 0.11 | 0.11 | 0.22 | 0.33 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0.75 | 0.25 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Nyctiophylax* | 0.11 | 0.67 | 0.11 | 0 | 0 | 0.11 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Oecetis* | 0.1 | 0.31 | 0.34 | 0.2 | 0.05 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0.5 | 0.5 | 0 | 0.75 | 0.25 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Oxyetira* | 0.05 | 0.66 | 0.24 | 0.06 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0.5 | 0.5 | 0 | 0 | 0.75 | 0.25 | 0 | 0.5 | 0 | 0.5 | 0 | 0 | 0 | 1 |
| *Phylloicus* | 0.05 | 0.21 | 0.19 | 0.13 | 0.3 | 0.11 | 0 | 1 | 0.25 | 0.75 | 0 | 0 | 0 | 0 | 0 | 0.75 | 0.25 | 0 | 0.75 | 0.25 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Polycentropus* | 0 | 0.12 | 0.19 | 0.27 | 0.41 | 0.02 | 1 | 0 | 0 | 0.2 | 0 | 0.2 | 0.6 | 0 | 0 | 0.5 | 0.5 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Polyplectropus* | 0 | 0.01 | 0.09 | 0.24 | 0.66 | 0 | 1 | 0 | 0 | 0.07 | 0 | 0.4 | 0.53 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Protoptila* | 0.05 | 0.47 | 0.34 | 0.14 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0.5 | 0.5 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0.4 | 0.6 |
| *Smicridea* | 0 | 0.25 | 0.25 | 0.24 | 0.24 | 0 | 0 | 1 | 0 | 0.2 | 0 | 0.6 | 0.2 | 0 | 0 | 0.33 | 0.5 | 0.17 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Triplectides* | 0 | 0.07 | 0.07 | 0.1 | 0.5 | 0.27 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0.75 | 0.25 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Wormaldia* | 0 | 0.91 | 0 | 0.03 | 0.06 | 0 | 1 | 0 | 0 | 0 | 0.4 | 0.6 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |

**Appendix 2:** Tables with all raw environmental variables and their codes and definitions sampled in each site used in the thesis.

**Table 2.1.** Geophysical variables

| | Drainage area ($km^2$) | Site altitude (m) | Range basin elevation (m) | Average basin elevation (m) | Std. Dev. Basin elevation | Range basin slope (%) | Average basin slope (%) | Std. Dev. Basin slope | Total annual rainfall ($mm/m^2$) |
|---|---|---|---|---|---|---|---|---|---|
| | **Dren_area** | **Altitude** | **Elev_range** | **Elev_mean** | **Elev_std** | **Slope_range** | **Slope_mean** | **Slope_std** | **Rainfall** |
| **TMMS0003** | 87.83 | 590 | 672.02 | 78.70 | 317.00 | 5.46 | 7.29 | 50.52 | 1184.673 |
| **TMMS0007** | 104.98 | 623 | 698.52 | 45.39 | 199.00 | 6.30 | 3.07 | 27.36 | 1198.299 |
| **TMMS0009** | 17.26 | 647 | 759.90 | 52.36 | 209.00 | 11.56 | 6.75 | 37.78 | 1355.000 |
| **TMMS0027** | 7.49 | 765 | 838.55 | 13.86 | 67.00 | 4.47 | 2.60 | 13.92 | 1261.700 |
| **TMMS0028** | 7.48 | 666 | 761.12 | 41.29 | 221.00 | 16.72 | 8.25 | 48.96 | 1412.444 |
| **TMMS0033** | 1.57 | 659 | 704.72 | 9.32 | 45.00 | 8.46 | 3.44 | 16.47 | 1364.000 |
| **TMMS0040** | 0.45 | 815 | 930.02 | 39.89 | 151.00 | 10.39 | 4.38 | 19.53 | 1449.000 |
| **TMMS0043** | 7.36 | 784 | 815.50 | 18.21 | 79.00 | 4.15 | 2.64 | 12.36 | 1264.625 |
| **TMMS0058** | 5.54 | 639 | 622.89 | 15.69 | 93.00 | 7.20 | 2.80 | 18.51 | 1267.571 |
| **TMMS0072** | 9.09 | 734 | 783.35 | 17.21 | 76.00 | 8.80 | 26.78 | 475.30 | 1386.167 |
| **TMMS0082** | 44.78 | 584 | 611.60 | 19.66 | 105.00 | 5.51 | 2.53 | 18.45 | 1363.558 |
| **TMMS0088** | 3.16 | 770 | 791.92 | 15.23 | 82.00 | 8.53 | 5.99 | 35.31 | 1376.250 |
| **TMMS0090** | 5.13 | 648 | 721.60 | 27.22 | 121.00 | 6.77 | 3.77 | 16.93 | 1303.250 |
| **TMMS0091** | 103.51 | 709 | 839.01 | 47.71 | 229.00 | 7.98 | 3.87 | 30.23 | 1253.375 |
| **TMMS0106** | 1.87 | 645 | 692.29 | 18.82 | 70.00 | 7.53 | 3.97 | 18.85 | 1262.000 |
| **TMMS0119** | 72.48 | 600 | 680.64 | 64.05 | 337.00 | 4.59 | 5.06 | 47.34 | 1184.565 |
| **TMMS0126** | 37.96 | 591 | 636.90 | 25.74 | 143.00 | 4.84 | 2.28 | 13.34 | 1204.156 |
| **TMMS0133** | 11.92 | 614 | 646.54 | 16.35 | 81.00 | 6.09 | 2.51 | 16.92 | 1319.133 |
| **TMMS0134** | 1.1 | 669 | 675.79 | 15.12 | 57.00 | 6.10 | 2.20 | 8.76 | 1222.000 |
| **TMMS0137** | 62.01 | 611 | 712.72 | 69.30 | 269.00 | 10.50 | 7.07 | 44.34 | 1338.819 |
| **TMMS0159** | 164.84 | 729 | 827.53 | 34.38 | 181.00 | 6.00 | 3.49 | 20.70 | 1257.568 |
| **TMMS0171** | 162.09 | 675 | 794.44 | 43.18 | 213.00 | 5.80 | 3.36 | 25.31 | 1258.631 |
| **TMMS0178** | 30.14 | 586 | 614.73 | 22.98 | 134.00 | 4.84 | 2.15 | 16.02 | 1277.027 |
| **TMMS0183** | 53.79 | 616 | 678.79 | 43.86 | 246.00 | 3.40 | 2.55 | 37.45 | 1186.000 |
| **TMMS0187** | 24.96 | 742 | 796.71 | 19.35 | 98.00 | 4.22 | 1.92 | 13.25 | 1265.563 |

| | Drainage area ($km^2$) | Site altitude (m) | Range basin elevation (m) | Average basin elevation (m) | Std. Dev. Basin elevation | Range basin slope (%) | Average basin slope (%) | Std. Dev. Basin slope | Total annual rainfall ($mm/m^2$) |
|---|---|---|---|---|---|---|---|---|---|
| | **Dren_area** | **Altitude** | **Elev_range** | **Elev_mean** | **Elev_std** | **Slope_range** | **Slope_mean** | **Slope_std** | **Rainfall** |
| **TMMS0193** | 109.1 | 621 | 673.05 | 23.19 | 133.00 | 6.24 | 7.88 | 396.25 | 1402.259 |
| **TMMS0209** | 53.25 | 637 | 642.13 | 18.35 | 89.00 | 5.74 | 2.74 | 18.46 | 1386.615 |
| **TMMS0214** | 44.44 | 636 | 680.00 | 29.64 | 167.00 | 4.77 | 2.30 | 15.33 | 1229.574 |
| **TMMS0220** | 10.91 | 671 | 813.19 | 36.92 | 181.00 | 14.24 | 8.76 | 52.18 | 1415.250 |
| **TMMS0279** | 157.1 | 642 | 754.23 | 39.61 | 255.00 | 5.95 | 3.56 | 25.03 | 1201.771 |
| **TMMS0283** | 55.27 | 753 | 834.13 | 23.95 | 132.00 | 4.44 | 2.52 | 14.14 | 1262.059 |
| **TMMS0290** | 22.96 | 606 | 630.16 | 16.84 | 68.00 | 5.04 | 2.21 | 16.41 | 1381.172 |
| **TMMS0296** | 24.57 | 682 | 871.57 | 68.93 | 380.00 | 14.81 | 8.28 | 47.73 | 1435.467 |
| **TMMS0381** | 106.73 | 587 | 688.66 | 79.65 | 291.00 | 10.44 | 8.02 | 55.99 | 1364.258 |
| **TMMS0391** | 71.31 | 652 | 717.39 | 41.53 | 186.00 | 6.29 | 3.09 | 27.36 | 1200.047 |
| **TMMS0437** | 30.14 | 594 | 703.82 | 50.45 | 234.00 | 9.78 | 6.59 | 36.89 | 1349.973 |
| **TMMS1865** | 65.84 | 608 | 707.65 | 70.36 | 272.00 | 10.15 | 7.02 | 44.34 | 1336.038 |
| **TMMS3195** | 3.39 | 739 | 775.07 | 11.59 | 53.00 | 3.67 | 2.16 | 9.73 | 1284.000 |
| **TMMS3962** | 20.45 | 599 | 735.84 | 70.20 | 269.00 | 11.85 | 8.39 | 49.20 | 1205.958 |
| **VGMS00002** | 2.64 | 769 | 808.52 | 74.00 | 20.92 | 4.63 | 1.94 | 10.59 | 1587.750 |
| **VGMS00004** | 16.38 | 593 | 707.67 | 231.00 | 55.61 | 7.96 | 4.56 | 30.92 | 1529.524 |
| **VGMS00016** | 7.78 | 602 | 725.14 | 200.00 | 38.56 | 4.72 | 3.12 | 21.71 | 1541.773 |
| **VGMS00018** | 3.28 | 737 | 812.81 | 120.00 | 27.44 | 4.66 | 2.25 | 10.62 | 1586.400 |
| **VGMS00022** | 3.07 | 701 | 795.55 | 158.00 | 39.22 | 8.70 | 5.01 | 22.22 | 1585.000 |
| **VGMS00034** | 5.07 | 736 | 802.63 | 108.00 | 26.20 | 6.16 | 2.67 | 15.73 | 1586.125 |
| **VGMS00037** | 11.22 | 585 | 658.07 | 123.00 | 27.37 | 4.27 | 2.69 | 16.18 | 1496.500 |
| **VGMS00044** | 6.87 | 709 | 755.38 | 91.00 | 17.19 | 4.05 | 2.88 | 16.40 | 1550.500 |
| **VGMS00048** | 12.06 | 581 | 637.60 | 97.00 | 20.66 | 3.84 | 2.55 | 15.78 | 1472.467 |
| **VGMS00080** | 25.5 | 593 | 686.30 | 174.00 | 32.58 | 4.17 | 3.11 | 28.30 | 1510.806 |
| **VGMS00109** | 20.96 | 625 | 706.57 | 161.00 | 30.42 | 5.29 | 2.66 | 18.52 | 1557.192 |
| **VGMS00112** | 52.83 | 576 | 692.60 | 229.00 | 49.49 | 4.62 | 2.82 | 18.44 | 1511.284 |
| **VGMS00121** | 8.53 | 598 | 676.51 | 121.00 | 28.49 | 5.51 | 2.69 | 13.88 | 1530.000 |
| **VGMS00124** | 25.62 | 683 | 749.48 | 115.00 | 22.22 | 3.85 | 2.53 | 15.54 | 1543.034 |
| **VGMS00126** | 6.68 | 674 | 780.85 | 177.00 | 35.28 | 6.43 | 3.95 | 29.99 | 1535.143 |
| **VGMS00128** | 4.87 | 584 | 639.33 | 100.00 | 21.88 | 6.23 | 3.03 | 18.32 | 1457.833 |

| | Drainage area (km²) | Site altitude (m) | Range basin elevation (m) | Average basin elevation (m) | Std. Dev. Basin elevation | Range basin slope (%) | Average basin slope (%) | Std. Dev. Basin slope | Total annual rainfall (mm/m²) |
|---|---|---|---|---|---|---|---|---|---|
| | **Dren_area** | **Altitude** | **Elev_range** | **Elev_mean** | **Elev_std** | **Slope_range** | **Slope_mean** | **Slope_std** | **Rainfall** |
| **VGMS00162** | 20.71 | 651 | 748.26 | 171.00 | 32.57 | 5.09 | 3.36 | 24.22 | 1571.962 |
| **VGMS00177** | 7.58 | 511 | 575.99 | 138.00 | 32.96 | 6.59 | 3.30 | 19.84 | 1432.909 |
| **VGMS00191** | 21.73 | 536 | 645.11 | 203.00 | 44.21 | 6.17 | 3.44 | 25.84 | 1518.702 |
| **VGMS00206** | 5.28 | 631 | 757.40 | 246.00 | 78.46 | 12.74 | 10.37 | 53.18 | 1542.875 |
| **VGMS00210** | 24.77 | 713 | 815.69 | 203.00 | 36.05 | 7.15 | 4.22 | 28.13 | 1591.250 |
| **VGMS00247** | 8.25 | 685 | 787.33 | 173.00 | 39.19 | 6.85 | 2.74 | 17.76 | 1535.500 |
| **VGMS00252** | 23.13 | 560 | 712.00 | 195.00 | 40.22 | 5.17 | 3.43 | 21.96 | 1535.374 |
| **VGMS00255** | 5.83 | 573 | 660.04 | 152.00 | 41.58 | 8.85 | 4.02 | 24.89 | 1532.000 |
| **VGMS00277** | 5.49 | 536 | 706.44 | 193.00 | 39.84 | 5.29 | 3.39 | 21.67 | 1532.366 |
| **VGMS00306** | 20.78 | 669 | 802.23 | 243.00 | 43.11 | 7.31 | 4.62 | 29.78 | 1586.200 |
| **VGMS00320** | 4.11 | 700 | 747.03 | 108.00 | 21.18 | 3.85 | 2.45 | 14.51 | 1524.000 |
| **VGMS00380** | 18.05 | 627 | 722.80 | 91.00 | 20.51 | 4.23 | 2.41 | 11.63 | 1530.475 |
| **VGMS00387** | 22.38 | 545 | 629.39 | 176.00 | 40.91 | 5.00 | 2.37 | 16.45 | 1493.333 |
| **VGMS00418** | 8.43 | 688 | 786.64 | 174.00 | 41.89 | 6.90 | 3.30 | 18.77 | 1581.333 |
| **VGMS00433** | 60.04 | 531 | 618.27 | 197.00 | 45.11 | 5.17 | 3.12 | 24.06 | 1477.148 |
| **VGMS00444** | 73.34 | 599 | 731.25 | 205.00 | 38.73 | 4.43 | 2.95 | 21.44 | 1544.347 |
| **VGMS00447** | 16.12 | 536 | 633.50 | 187.00 | 48.68 | 7.97 | 4.24 | 22.87 | 1527.279 |
| **VGMS00450** | 46.46 | 669 | 813.28 | 316.00 | 61.72 | 6.93 | 4.66 | 29.94 | 1587.877 |
| **VGMS00511** | 5.05 | 603 | 700.57 | 167.00 | 41.09 | 7.48 | 3.37 | 23.08 | 1533.125 |
| **VGMS00515** | 19.92 | 555 | 705.70 | 239.00 | 54.15 | 8.62 | 5.30 | 34.33 | 1518.182 |
| **VGMS00558** | 12.16 | 612 | 845.24 | 267.00 | 31.74 | 5.36 | 5.89 | 61.32 | 1556.125 |
| **VGMS00575** | 8.51 | 626 | 722.79 | 182.00 | 42.92 | 6.71 | 3.16 | 21.61 | 1537.300 |
| **SSMS0001** | 3.32 | 705 | 736.22 | 69.00 | 16.37 | 3.68 | 1.17 | 7.11 | 1589.250 |
| **SSMS0002** | 32.68 | 484 | 577.85 | 222.00 | 29.71 | 4.14 | 2.47 | 33.33 | 1386.390 |
| **SSMS0008** | 6.05 | 601 | 687.70 | 135.00 | 35.24 | 6.13 | 3.42 | 18.75 | 1299.429 |
| **SSMS0010** | 38.24 | 434 | 484.31 | 114.00 | 22.23 | 3.25 | 1.34 | 10.59 | 1453.915 |
| **SSMS0014** | 8.96 | 478 | 534.15 | 91.00 | 16.73 | 3.10 | 1.30 | 10.51 | 1526.091 |
| **SSMS0028** | 17.52 | 471 | 557.27 | 203.00 | 54.27 | 4.65 | 2.05 | 17.04 | 1437.429 |
| **SSMS0029** | 70.14 | 409 | 522.01 | 226.00 | 50.18 | 3.79 | 1.95 | 13.64 | 1444.483 |
| **SSMS0031** | 2.13 | 541 | 579.59 | 186.00 | 41.39 | 8.53 | 8.25 | 43.40 | 1548.000 |

| | Drainage area (km²) | Site altitude (m) | Range basin elevation (m) | Average basin elevation (m) | Std. Dev. Basin elevation | Range basin slope (%) | Average basin slope (%) | Std. Dev. Basin slope | Total annual rainfall (mm/m²) |
|---|---|---|---|---|---|---|---|---|---|
| | **Dren_area** | **Altitude** | **Elev_range** | **Elev_mean** | **Elev_std** | **Slope_range** | **Slope_mean** | **Slope_std** | **Rainfall** |
| **SSMS0033** | 18.05 | 462 | 516.10 | 178.00 | 32.18 | 5.98 | 6.24 | 45.52 | 1458.636 |
| **SSMS0035** | 108.36 | 479 | 587.74 | 293.00 | 83.36 | 6.75 | 7.65 | 47.03 | 1533.582 |
| **SSMS0037** | 31.59 | 491 | 567.25 | 251.00 | 33.95 | 4.70 | 3.85 | 48.72 | 1442.237 |
| **SSMS0038** | 27.95 | 489 | 555.94 | 190.00 | 36.44 | 6.72 | 5.41 | 36.57 | 1492.361 |
| **SSMS0044** | 68.3 | 458 | 559.52 | 229.00 | 56.51 | 4.35 | 2.39 | 19.22 | 1369.679 |
| **SSMS0051** | 12.84 | 502 | 571.24 | 136.00 | 37.58 | 3.73 | 1.78 | 15.62 | 1459.933 |
| **SSMS0053** | 4.02 | 512 | 558.78 | 83.00 | 22.37 | 4.04 | 1.72 | 8.44 | 1438.750 |
| **SSMS0057** | 3.44 | 496 | 528.31 | 174.00 | 31.25 | 7.18 | 7.32 | 46.10 | 1466.250 |
| **SSMS0059** | 4.77 | 521 | 565.81 | 191.00 | 24.90 | 6.33 | 6.53 | 47.90 | 1548.000 |
| **SSMS0073** | 67.92 | 453 | 572.75 | 225.00 | 47.53 | 4.34 | 2.69 | 25.60 | 1418.557 |
| **SSMS0078** | 18.28 | 491 | 659.95 | 273.00 | 86.26 | 9.65 | 10.42 | 52.40 | 1567.773 |
| **SSMS0094** | 9.99 | 490 | 533.44 | 107.00 | 19.29 | 3.55 | 1.43 | 16.29 | 1518.500 |
| **SSMS0105** | 19.34 | 410 | 491.73 | 130.00 | 25.54 | 4.13 | 1.81 | 11.50 | 1468.348 |
| **SSMS0126** | 23.48 | 424 | 578.70 | 325.00 | 94.08 | 6.35 | 6.49 | 41.11 | 1540.103 |
| **SSMS0129** | 70.68 | 468 | 551.42 | 246.00 | 57.55 | 9.09 | 9.32 | 52.19 | 1476.600 |
| **SSMS0133** | 43.31 | 475 | 544.55 | 247.00 | 32.79 | 5.62 | 5.45 | 57.13 | 1390.019 |
| **SSMS0144** | 17.52 | 446 | 532.37 | 200.00 | 53.01 | 4.04 | 2.26 | 15.44 | 1430.850 |
| **SSMS0149** | 43.23 | 485 | 548.38 | 182.00 | 29.99 | 4.67 | 2.76 | 43.16 | 1451.259 |
| **SSMS0150** | 25.29 | 478 | 550.41 | 209.00 | 39.78 | 6.64 | 6.25 | 49.99 | 1492.290 |
| **SSMS0157** | 2.44 | 579 | 617.21 | 59.00 | 14.02 | 3.81 | 1.45 | 7.23 | 1394.000 |
| **SSMS0175** | 7.74 | 506 | 563.45 | 204.00 | 32.33 | 5.67 | 5.04 | 35.42 | 1535.111 |
| **SSMS0191** | 18.27 | 531 | 632.44 | 313.00 | 80.74 | 9.09 | 9.36 | 48.94 | 1584.391 |
| **SSMS0193** | 70.68 | 468 | 551.42 | 246.00 | 57.55 | 9.09 | 9.32 | 52.19 | 1476.600 |
| **SSMS0199** | 40.75 | 411 | 477.87 | 220.00 | 45.03 | 3.35 | 2.52 | 25.44 | 1435.860 |
| **SSMS0213** | 46.14 | 457 | 535.06 | 144.00 | 24.48 | 3.97 | 1.59 | 11.10 | 1453.276 |
| **SSMS0351** | 42.43 | 450 | 558.38 | 291.00 | 64.09 | 7.15 | 7.20 | 48.89 | 1539.182 |
| **SSMS0408** | 18.2 | 438 | 514.02 | 151.00 | 37.06 | 6.52 | 4.64 | 29.41 | 1357.273 |
| **SSMS0411** | 93.46 | 499 | 626.72 | 336.00 | 79.83 | 7.25 | 8.85 | 74.85 | 1559.345 |
| **SSMS0447** | 30.76 | 521 | 597.19 | 272.00 | 51.85 | 6.89 | 6.53 | 49.56 | 1567.339 |
| **SSMS1000** | 11.96 | 460 | 560.99 | 178.00 | 38.26 | 4.75 | 2.68 | 15.57 | 1419.857 |

| | Drainage area (km²) | Site altitude (m) | Range basin elevation (m) | Average basin elevation (m) | Std. Dev. Basin elevation | Range basin slope (%) | Average basin slope (%) | Std. Dev. Basin slope | Total annual rainfall (mm/m²) |
|---|---|---|---|---|---|---|---|---|---|
| | **Dren_area** | **Altitude** | **Elev_range** | **Elev_mean** | **Elev_std** | **Slope_range** | **Slope_mean** | **Slope_std** | **Rainfall** |
| **SSMS4173** | 0.37 | 513 | 530.62 | 43.00 | 11.00 | 8.10 | 3.54 | 14.86 | 1333.000 |
| **SSMS4330** | 36.23 | 431 | 514.30 | 236.00 | 59.14 | 6.19 | 5.42 | 28.93 | 1260.591 |
| **RENP0008** | 7.72 | 920 | 1012.28 | 106.00 | 26.63 | 5.63 | 5.00 | 21.79 | 1558.500 |
| **RENP0012** | 4.19 | 871 | 1011.62 | 226.00 | 62.88 | 14.01 | 5.66 | 29.64 | 1619.714 |
| **RENP0016** | 32.73 | 835 | 997.77 | 345.00 | 81.76 | 14.44 | 8.98 | 56.74 | 1566.462 |
| **RENP0028** | 15.05 | 846 | 934.74 | 208.00 | 31.24 | 8.32 | 3.98 | 25.50 | 1568.368 |
| **RENP0047** | 1.73 | 900 | 960.54 | 84.00 | 20.23 | 7.71 | 3.56 | 15.24 | 1611.000 |
| **RENP0052** | 6.02 | 856 | 954.11 | 131.00 | 34.08 | 6.62 | 4.21 | 19.53 | 1552.429 |
| **RENP0054** | 50.75 | 845 | 989.04 | 355.00 | 67.58 | 10.95 | 7.27 | 45.71 | 1557.092 |
| **RENP0055** | 10.41 | 947 | 1024.34 | 123.00 | 24.88 | 6.26 | 2.65 | 15.52 | 1529.250 |
| **RENP0075** | 5.31 | 855 | 944.61 | 176.00 | 47.32 | 11.11 | 5.38 | 30.83 | 1544.667 |
| **RENP0092** | 1.69 | 940 | 1030.61 | 190.00 | 47.24 | 17.16 | 8.19 | 40.83 | 1608.333 |
| **RENP0095** | 3.22 | 897 | 924.71 | 84.00 | 19.58 | 5.90 | 2.36 | 12.60 | 1547.200 |
| **RENP0096** | 17.33 | 817 | 895.96 | 108.00 | 21.13 | 6.20 | 3.46 | 24.13 | 1519.300 |
| **RENP0097** | 7.34 | 865 | 1014.02 | 203.00 | 51.74 | 8.50 | 5.78 | 26.88 | 1516.500 |
| **RENP0100** | 8.65 | 823 | 972.03 | 307.00 | 62.20 | 8.92 | 5.61 | 30.22 | 1564.700 |
| **RENP0108** | 3.40 | 860 | 924.23 | 79.00 | 18.13 | 6.10 | 2.40 | 14.49 | 1590.000 |
| **RENP0110** | 6.80 | 893 | 1007.63 | 147.00 | 34.97 | 7.66 | 4.17 | 17.95 | 1621.571 |
| **RENP0112** | 7.28 | 877 | 943.79 | 104.00 | 22.16 | 6.03 | 2.89 | 15.14 | 1494.222 |
| **RENP0128** | 2.82 | 841 | 949.57 | 206.00 | 67.38 | 11.72 | 7.01 | 35.53 | 1504.000 |
| **RENP0132** | 1.38 | 854 | 905.49 | 140.00 | 27.47 | 7.74 | 4.18 | 20.87 | 1556.500 |
| **RENP0139** | 15.41 | 863 | 942.17 | 117.00 | 22.89 | 5.34 | 2.78 | 18.44 | 1497.316 |
| **RENP0144** | 3.65 | 826 | 910.63 | 204.00 | 45.06 | 11.36 | 4.73 | 25.45 | 1503.000 |
| **RENP0187** | 6.37 | 891 | 933.67 | 98.00 | 22.10 | 7.12 | 3.89 | 19.06 | 1585.286 |
| **RENP0192** | 23.60 | 910 | 1007.22 | 110.00 | 26.44 | 3.44 | 3.05 | 15.53 | 1555.000 |
| **RENP0203** | 15.48 | 888 | 1004.53 | 201.00 | 47.07 | 11.56 | 5.97 | 37.33 | 1531.211 |
| **RENP0228** | 4.58 | 870 | 961.00 | 116.00 | 29.05 | 6.84 | 3.31 | 17.29 | 1537.400 |
| **RENP0240** | 1.54 | 960 | 1029.03 | 84.00 | 23.92 | 7.30 | 6.02 | 19.64 | 1570.500 |
| **RENP0251** | 3.15 | 909 | 971.97 | 94.00 | 24.41 | 8.64 | 4.52 | 19.37 | 1602.000 |
| **RENP0287** | 16.96 | 833 | 899.57 | 132.00 | 29.30 | 7.55 | 3.79 | 21.02 | 1561.850 |

| | Drainage area (km²) | Site altitude (m) | Range basin elevation (m) | Average basin elevation (m) | Std. Dev. Basin elevation | Range basin slope (%) | Average basin slope (%) | Std. Dev. Basin slope | Total annual rainfall (mm/m²) |
|---|---|---|---|---|---|---|---|---|---|
| | **Dren_area** | **Altitude** | **Elev_range** | **Elev_mean** | **Elev_std** | **Slope_range** | **Slope_mean** | **Slope_std** | **Rainfall** |
| **RENP0368** | 7.37 | 967 | 940.11 | 117.00 | 24.22 | 5.22 | 2.74 | 16.07 | 1496.111 |
| **RENP0375** | 2.32 | 948 | 1004.08 | 104.00 | 24.70 | 10.99 | 5.54 | 31.61 | 1537.333 |
| **RENP0443** | 13.40 | 887 | 951.22 | 111.00 | 25.89 | 7.75 | 4.16 | 21.87 | 1601.111 |
| **RENP0511** | 28.74 | 868 | 919.92 | 142.00 | 29.20 | 7.50 | 4.18 | 26.27 | 1631.771 |
| **RENP1524** | 7.93 | 914 | 1019.94 | 94.00 | 18.35 | 3.16 | 3.07 | 15.78 | 1550.667 |
| **RENP2991** | 5.90 | 895 | 947.69 | 116.00 | 25.40 | 8.18 | 3.72 | 20.78 | 1657.429 |
| **RENP5612** | 29.63 | 954 | 1035.86 | 119.00 | 25.14 | 4.27 | 3.49 | 18.17 | 1594.676 |
| **RENP7308** | 1.39 | 839 | 906.89 | 85.00 | 21.51 | 9.00 | 4.67 | 21.11 | 1567.500 |
| **RENP9611** | 2.92 | 860 | 912.57 | 93.00 | 21.83 | 6.99 | 2.81 | 13.41 | 1565.750 |
| **RENP9757** | 10.81 | 952 | 1036.58 | 171.00 | 35.46 | 8.95 | 4.37 | 21.31 | 1618.308 |
| **RENP12892** | 6.90 | 904 | 980.29 | 209.00 | 45.78 | 12.34 | 6.18 | 34.44 | 1599.667 |
| **RENP15048** | 27.83 | 931 | 1011.11 | 128.00 | 32.92 | 5.13 | 3.65 | 17.95 | 1569.811 |
| **RCA02** | 0.14 | 1203 | 1067.6 | 58 | 16.10 | 11.06 | 2.90 | 9.22 | 1542.000 |
| **RCA08** | 5.07 | 917 | 1054.87 | 243 | 46.47 | 12.65 | 5.51 | 35.00 | 1634.333 |
| **RCA22** | 3.85 | 1218 | 1321.28 | 134 | 34.14 | 6.41 | 3.13 | 16.49 | 1600.333 |
| **RCA23** | 3.29 | 1240 | 1309.66 | 173 | 44.00 | 8.02 | 3.70 | 19.40 | 1603.250 |
| **RCA30** | 0.13 | 1243 | 1243.79 | 41 | 12.81 | 12.35 | 6.56 | 22.28 | 1579.000 |
| **RCA31** | 3.07 | 1033 | 1081.63 | 99 | 26.72 | 8.74 | 4.02 | 18.32 | 1632.667 |
| **RCA44** | 0.32 | 995 | 1031.63 | 64 | 17.28 | 9.06 | 3.43 | 13.51 | 1634.000 |
| **RCA48** | 9.2 | 828 | 973.11 | 318 | 66.27 | 8.74 | 5.69 | 33.76 | 1563.231 |
| **RCA49** | 0.77 | 836 | 886.32 | 125 | 38.68 | 13.55 | 9.11 | 35.15 | 1533.000 |
| **RCA50** | 4.73 | 1217 | 959.19 | 280 | 72.35 | 15.82 | 7.86 | 38.63 | 1562.000 |
| **RCA52** | 21.76 | 900 | 1017.83 | 282 | 52.26 | 9.10 | 6.74 | 46.43 | 1559.233 |
| **RCA53** | 5.46 | 876 | 1012.16 | 271 | 78.98 | 15.02 | 9.35 | 43.94 | 1573.000 |
| **RCA57** | 5.53 | 1245 | 1332.56 | 178 | 41.18 | 7.69 | 4.14 | 24.51 | 1611.833 |
| **RCA58** | 3.74 | 1210 | 1312.39 | 143 | 34.31 | 7.15 | 3.68 | 18.65 | 1601.250 |
| **RCA59** | 11.02 | 1220 | 1320.87 | 193 | 44.98 | 6.86 | 3.95 | 20.64 | 1615.818 |
| **RCA60** | 6.67 | 1215 | 1279.83 | 145 | 33.05 | 7.97 | 4.49 | 21.24 | 1611.857 |
| **RCA62** | 14.69 | 1199 | 939.27 | 190 | 44.80 | 9.56 | 4.52 | 28.36 | 1536.750 |
| **RCA64** | 16.26 | 1039 | 1002.58 | 212 | 47.80 | 11.26 | 5.71 | 31.66 | 1531.500 |

| | Drainage area ($km^2$) | Site altitude (m) | Range basin elevation (m) | Average basin elevation (m) | Std. Dev. Basin elevation | Range basin slope (%) | Average basin slope (%) | Std. Dev. Basin slope | Total annual rainfall ($mm/m^2$) |
|---|---|---|---|---|---|---|---|---|---|
| | **Dren_area** | **Altitude** | **Elev_range** | **Elev_mean** | **Elev_std** | **Slope_range** | **Slope_mean** | **Slope_std** | **Rainfall** |
| **RCA65** | 12.41 | 1048 | 1312.41 | 162 | 34.70 | 6.73 | 3.11 | 18.35 | 1600.688 |
| **RCA66** | 0.72 | 997 | 1071.25 | 123 | 38.31 | 12.72 | 7.22 | 27.06 | 1623.000 |
| **RCA67** | 0.78 | 903 | 975.70 | 155 | 41.75 | 13.26 | 4.11 | 17.98 | 1603.000 |
| **RCA68** | 6.52 | 927 | 1025.44 | 285 | 87.02 | 12.26 | 7.72 | 43.78 | 1565.500 |
| **RCA69** | 6.52 | 851 | 1025.59 | 285 | 87.03 | 12.32 | 7.70 | 43.78 | 1565.500 |
| **RCA70** | 2.49 | 840 | 904.38 | 190 | 48.02 | 13.14 | 7.90 | 33.45 | 1547.000 |
| **RCA71** | 1.56 | 852 | 905.54 | 91 | 21.50 | 8.86 | 3.87 | 18.38 | 1567.500 |
| **RCA72** | 4.15 | 898 | 919.33 | 204 | 47.34 | 9.61 | 5.00 | 34.12 | 1532.250 |
| **RCA73** | 50.77 | 863 | 949.64 | 342 | 59.59 | 12.09 | 6.97 | 44.43 | 1555.894 |
| **RCA74** | 2.29 | 858 | 979.33 | 114 | 25.50 | 10.50 | 5.25 | 26.54 | 1562.000 |
| **RCA90** | 2.29 | 916 | 979.81 | 114 | 25.25 | 10.57 | 5.22 | 26.54 | 1562.000 |

**Table 2.2.** Land use variables.

| | % of Woodland savanna | % of Parkland savanna | % of Grassy-woody savanna | % of Palm swamp | % of Pasture | % of Agriculture |
|---|---|---|---|---|---|---|
| | **%_Woodland** | **%_Parkland** | **%_Grassy_Woody** | **%_Palm_swamp** | **%_Pasture** | **%_Agriculture** |
| **TMMS0003** | 9.20 | 4.92 | 6.56 | 1.70 | 61.10 | 3.83 |
| **TMMS0007** | 8.93 | 27.59 | 7.10 | 0.00 | 34.85 | 1.21 |
| **TMMS0009** | 48.87 | 9.86 | 10.07 | 0.00 | 31.21 | 0.00 |
| **TMMS0027** | 8.16 | 0.74 | 19.01 | 1.72 | 35.21 | 0.34 |
| **TMMS0028** | 56.19 | 24.81 | 0.00 | 0.00 | 19.00 | 0.00 |
| **TMMS0033** | 11.23 | 20.69 | 18.63 | 0.00 | 41.12 | 0.00 |
| **TMMS0040** | 16.18 | 4.71 | 11.00 | 0.00 | 68.11 | 0.00 |
| **TMMS0043** | 5.68 | 9.80 | 29.57 | 0.00 | 28.40 | 8.91 |
| **TMMS0058** | 7.31 | 24.24 | 6.69 | 0.00 | 59.94 | 0.00 |
| **TMMS0072** | 24.13 | 23.77 | 3.55 | 0.00 | 45.42 | 3.12 |
| **TMMS0082** | 12.30 | 3.39 | 5.81 | 2.97 | 72.23 | 1.70 |
| **TMMS0088** | 4.72 | 74.71 | 0.00 | 0.00 | 20.57 | 0.00 |
| **TMMS0090** | 21.33 | 21.48 | 6.70 | 0.00 | 44.63 | 1.60 |
| **TMMS0091** | 16.32 | 20.07 | 11.97 | 0.00 | 49.71 | 0.94 |
| **TMMS0106** | 9.32 | 30.73 | 11.24 | 0.00 | 38.43 | 0.00 |
| **TMMS0119** | 10.98 | 6.64 | 7.94 | 0.74 | 60.05 | 1.53 |
| **TMMS0126** | 8.34 | 17.43 | 24.69 | 0.00 | 7.64 | 4.74 |
| **TMMS0133** | 10.06 | 4.24 | 10.30 | 0.71 | 63.49 | 2.72 |
| **TMMS0134** | 2.36 | 93.76 | 0.00 | 0.00 | 3.89 | 0.00 |
| **TMMS0137** | 37.37 | 18.54 | 5.50 | 0.15 | 37.54 | 0.65 |
| **TMMS0159** | 8.37 | 31.50 | 8.47 | 0.89 | 16.32 | 1.74 |
| **TMMS0171** | 7.82 | 34.23 | 18.82 | 0.79 | 24.24 | 1.59 |
| **TMMS0178** | 15.26 | 2.18 | 11.57 | 0.00 | 64.33 | 2.11 |
| **TMMS0183** | 4.92 | 3.60 | 12.32 | 2.41 | 48.42 | 5.42 |
| **TMMS0187** | 8.63 | 10.43 | 27.25 | 0.00 | 46.24 | 7.44 |
| **TMMS0193** | 7.66 | 0.64 | 1.33 | 4.59 | 69.90 | 1.06 |
| **TMMS0209** | 17.70 | 1.05 | 1.39 | 4.32 | 38.45 | 14.50 |
| **TMMS0214** | 7.07 | 7.78 | 8.52 | 0.54 | 48.85 | 16.69 |
| **TMMS0220** | 43.55 | 20.33 | 5.48 | 0.00 | 30.64 | 0.00 |
| **TMMS0279** | 8.88 | 13.60 | 8.68 | 1.65 | 38.70 | 13.45 |

| | % of Woodland savanna | % of Parkland savanna | % of Grassy-woody savanna | % of Palm swamp | % of Pasture | % of Agriculture |
|---|---|---|---|---|---|---|
| | **%_Woodland** | **%_Parkland** | **%_Grassy_Woody** | **%_Palm_swamp** | **%_Pasture** | **%_Agriculture** |
| **TMMS0283** | 6.70 | 19.98 | 31.49 | 1.50 | 17.38 | 2.51 |
| **TMMS0290** | 10.34 | 0.00 | 6.66 | 6.16 | 72.08 | 4.75 |
| **TMMS0296** | 29.60 | 29.64 | 11.94 | 0.00 | 28.83 | 0.00 |
| **TMMS0381** | 28.04 | 8.10 | 10.23 | 1.55 | 50.87 | 0.96 |
| **TMMS0391** | 9.91 | 24.05 | 3.35 | 0.00 | 32.92 | 0.68 |
| **TMMS0437** | 21.50 | 6.96 | 2.47 | 1.85 | 63.74 | 3.49 |
| **TMMS1865** | 35.73 | 18.49 | 5.43 | 0.89 | 37.99 | 1.24 |
| **TMMS3195** | 1.55 | 0.00 | 36.11 | 18.96 | 23.99 | 5.04 |
| **TMMS3962** | 24.87 | 32.97 | 4.13 | 0.00 | 32.06 | 5.97 |
| **VGMS00002** | 19.23 | 0.00 | 0.00 | 0.00 | 0.00 | 80.77 |
| **VGMS00004** | 12.88 | 0.00 | 1.84 | 0.00 | 17.79 | 67.48 |
| **VGMS00016** | 10.02 | 0.00 | 1.94 | 0.11 | 28.36 | 50.00 |
| **VGMS00018** | 9.09 | 0.00 | 0.00 | 0.00 | 0.00 | 90.91 |
| **VGMS00022** | 9.68 | 0.00 | 0.00 | 0.00 | 0.00 | 90.32 |
| **VGMS00034** | 10.00 | 0.00 | 0.00 | 0.00 | 0.00 | 90.00 |
| **VGMS00037** | 6.31 | 0.00 | 2.70 | 0.00 | 11.71 | 79.28 |
| **VGMS00044** | 10.14 | 0.00 | 0.00 | 0.00 | 47.83 | 37.68 |
| **VGMS00048** | 8.20 | 0.00 | 1.64 | 0.00 | 11.48 | 78.69 |
| **VGMS00080** | 9.02 | 0.00 | 1.57 | 0.78 | 7.06 | 81.57 |
| **VGMS00109** | 11.00 | 0.00 | 1.91 | 0.00 | 3.35 | 83.73 |
| **VGMS00112** | 10.82 | 0.00 | 1.33 | 0.57 | 12.90 | 70.78 |
| **VGMS00121** | 4.71 | 0.00 | 0.00 | 0.00 | 28.24 | 67.06 |
| **VGMS00124** | 10.55 | 0.00 | 4.69 | 0.00 | 26.95 | 44.53 |
| **VGMS00126** | 18.18 | 0.00 | 0.00 | 0.00 | 12.12 | 69.70 |
| **VGMS00128** | 18.37 | 0.00 | 0.00 | 0.00 | 6.12 | 67.35 |
| **VGMS00162** | 12.14 | 0.00 | 0.00 | 0.00 | 2.43 | 83.50 |
| **VGMS00177** | 6.67 | 0.00 | 0.00 | 2.67 | 5.33 | 85.33 |
| **VGMS00191** | 9.16 | 0.00 | 1.57 | 0.26 | 10.47 | 73.82 |
| **VGMS00206** | 22.64 | 0.00 | 3.77 | 0.00 | 13.21 | 60.38 |
| **VGMS00210** | 29.44 | 0.00 | 0.40 | 0.00 | 18.15 | 52.02 |
| **VGMS00247** | 8.54 | 0.00 | 0.00 | 0.00 | 0.00 | 91.46 |
| **VGMS00252** | 9.73 | 0.00 | 2.88 | 0.09 | 24.32 | 55.41 |

| | % of Woodland savanna | % of Parkland savanna | % of Grassy-woody savanna | % of Palm swamp | % of Pasture | % of Agriculture |
|---|---|---|---|---|---|---|
| | **%_Woodland** | **%_Parkland** | **%_Grassy_Woody** | **%_Palm_swamp** | **%_Pasture** | **%_Agriculture** |
| **VGMS00255** | 11.98 | 0.00 | 3.65 | 0.00 | 10.42 | 73.96 |
| **VGMS00277** | 9.79 | 0.00 | 2.83 | 0.09 | 23.26 | 56.82 |
| **VGMS00306** | 24.31 | 0.00 | 0.40 | 0.00 | 12.25 | 63.04 |
| **VGMS00320** | 9.52 | 0.00 | 0.00 | 4.76 | 14.29 | 71.43 |
| **VGMS00380** | 13.66 | 0.00 | 3.78 | 0.42 | 25.21 | 49.79 |
| **VGMS00387** | 3.14 | 0.00 | 0.00 | 4.93 | 1.35 | 90.58 |
| **VGMS00418** | 14.29 | 0.00 | 0.00 | 0.00 | 0.00 | 85.71 |
| **VGMS00433** | 9.35 | 0.00 | 2.34 | 0.17 | 3.51 | 84.64 |
| **VGMS00444** | 9.50 | 0.00 | 1.63 | 0.13 | 27.63 | 50.63 |
| **VGMS00447** | 11.30 | 0.00 | 2.26 | 0.00 | 6.78 | 78.53 |
| **VGMS00450** | 19.35 | 0.00 | 0.81 | 0.00 | 9.07 | 70.56 |
| **VGMS00511** | 13.33 | 0.00 | 2.96 | 0.00 | 8.89 | 74.81 |
| **VGMS00515** | 17.42 | 0.00 | 3.79 | 0.00 | 16.29 | 62.50 |
| **VGMS00558** | 8.26 | 0.00 | 0.00 | 0.83 | 9.09 | 71.07 |
| **VGMS00575** | 13.10 | 0.00 | 3.57 | 0.00 | 8.33 | 75.00 |
| **SSMS0001** | 5.92 | 0.00 | 0.00 | 0.00 | 0.00 | 94.08 |
| **SSMS0002** | 15.27 | 0.00 | 2.45 | 0.00 | 13.29 | 65.82 |
| **SSMS0008** | 14.09 | 0.00 | 3.38 | 0.00 | 1.93 | 80.60 |
| **SSMS0010** | 5.39 | 0.00 | 0.00 | 5.85 | 12.39 | 76.36 |
| **SSMS0014** | 2.18 | 0.00 | 0.00 | 3.78 | 24.75 | 69.29 |
| **SSMS0028** | 7.29 | 0.00 | 0.00 | 3.21 | 0.00 | 88.14 |
| **SSMS0029** | 6.62 | 0.00 | 0.00 | 2.66 | 0.00 | 90.73 |
| **SSMS0031** | 17.56 | 5.38 | 0.00 | 11.33 | 3.71 | 62.03 |
| **SSMS0033** | 11.85 | 13.00 | 0.92 | 0.31 | 49.87 | 21.21 |
| **SSMS0035** | 24.34 | 0.00 | 1.11 | 2.20 | 20.74 | 50.25 |
| **SSMS0037** | 10.98 | 0.00 | 2.59 | 3.05 | 7.48 | 75.89 |
| **SSMS0038** | 21.44 | 0.00 | 1.60 | 2.47 | 2.93 | 66.27 |
| **SSMS0044** | 9.05 | 0.00 | 0.31 | 3.16 | 2.11 | 85.38 |
| **SSMS0051** | 12.32 | 0.00 | 1.86 | 1.16 | 1.89 | 82.77 |
| **SSMS0053** | 10.52 | 0.00 | 0.00 | 0.00 | 0.00 | 89.48 |
| **SSMS0057** | 18.18 | 0.11 | 0.00 | 0.00 | 61.35 | 20.36 |
| **SSMS0059** | 13.81 | 2.27 | 8.70 | 5.22 | 2.35 | 67.66 |

| | % of Woodland savanna | % of Parkland savanna | % of Grassy-woody savanna | % of Palm swamp | % of Pasture | % of Agriculture |
|---|---|---|---|---|---|---|
| | **%_Woodland** | **%_Parkland** | **%_Grassy_Woody** | **%_Palm_swamp** | **%_Pasture** | **%_Agriculture** |
| **SSMS0073** | 10.95 | 0.00 | 0.53 | 0.08 | 0.00 | 83.87 |
| **SSMS0078** | 24.89 | 0.00 | 0.00 | 1.48 | 10.66 | 61.74 |
| **SSMS0094** | 8.78 | 0.00 | 0.00 | 0.00 | 8.90 | 82.32 |
| **SSMS0105** | 8.19 | 0.00 | 3.64 | 2.69 | 0.00 | 85.48 |
| **SSMS0126** | 19.48 | 0.00 | 0.00 | 0.20 | 13.77 | 66.54 |
| **SSMS0129** | 12.14 | 0.00 | 0.65 | 2.08 | 7.20 | 72.12 |
| **SSMS0133** | 13.68 | 3.27 | 4.49 | 0.00 | 16.31 | 60.63 |
| **SSMS0144** | 6.45 | 0.00 | 4.03 | 2.60 | 0.00 | 86.93 |
| **SSMS0149** | 13.55 | 0.58 | 0.00 | 3.97 | 26.76 | 55.14 |
| **SSMS0150** | 10.56 | 0.00 | 2.33 | 8.49 | 13.17 | 62.39 |
| **SSMS0157** | 8.00 | 0.00 | 0.00 | 0.00 | 0.00 | 92.00 |
| **SSMS0175** | 22.72 | 2.55 | 0.00 | 4.18 | 2.78 | 67.78 |
| **SSMS0191** | 25.08 | 2.75 | 0.00 | 4.56 | 11.25 | 56.36 |
| **SSMS0193** | 12.14 | 0.00 | 0.65 | 2.08 | 7.20 | 72.12 |
| **SSMS0199** | 14.54 | 0.00 | 0.54 | 6.72 | 1.06 | 77.15 |
| **SSMS0213** | 7.00 | 0.00 | 1.72 | 5.17 | 52.10 | 32.58 |
| **SSMS0351** | 16.11 | 1.65 | 1.61 | 2.29 | 16.33 | 62.01 |
| **SSMS0408** | 20.12 | 0.00 | 1.24 | 1.35 | 0.76 | 76.53 |
| **SSMS0411** | 25.82 | 1.00 | 0.00 | 1.21 | 8.44 | 63.54 |
| **SSMS0447** | 16.23 | 1.03 | 0.00 | 4.87 | 9.69 | 67.00 |
| **SSMS1000** | 14.00 | 0.00 | 0.69 | 0.29 | 0.00 | 85.02 |
| **SSMS4173** | 0.00 | 0.00 | 15.48 | 0.00 | 0.00 | 0.00 |
| **SSMS4330** | 19.53 | 0.00 | 0.00 | 0.67 | 4.90 | 72.44 |
| **RENP0008** | 8.89 | 0.00 | 4.99 | 2.15 | 3.99 | 79.99 |
| **RENP0012** | 30.06 | 0.00 | 57.52 | 0.00 | 11.40 | 1.02 |
| **RENP0016** | 11.89 | 81.18 | 0.00 | 0.00 | 2.39 | 4.54 |
| **RENP0028** | 17.72 | 0.00 | 13.11 | 0.00 | 15.32 | 53.84 |
| **RENP0047** | 27.72 | 0.00 | 8.24 | 0.00 | 38.60 | 25.44 |
| **RENP0052** | 8.26 | 0.00 | 21.51 | 0.00 | 15.55 | 54.68 |
| **RENP0054** | 10.56 | 56.83 | 0.00 | 0.00 | 12.69 | 19.91 |
| **RENP0055** | 9.38 | 0.00 | 0.00 | 0.00 | 0.00 | 90.62 |
| **RENP0075** | 5.84 | 88.31 | 0.00 | 0.00 | 0.00 | 5.85 |

| | % of Woodland savanna | % of Parkland savanna | % of Grassy-woody savanna | % of Palm swamp | % of Pasture | % of Agriculture |
|---|---|---|---|---|---|---|
| | **%_Woodland** | **%_Parkland** | **%_Grassy_Woody** | **%_Palm_swamp** | **%_Pasture** | **%_Agriculture** |
| **RENP0092** | 21.33 | 0.00 | 0.00 | 2.10 | 70.80 | 5.78 |
| **RENP0095** | 12.69 | 0.00 | 0.00 | 0.00 | 2.48 | 84.83 |
| **RENP0096** | 12.68 | 0.00 | 0.85 | 0.00 | 5.08 | 81.39 |
| **RENP0097** | 19.31 | 0.00 | 2.50 | 0.00 | 31.98 | 46.21 |
| **RENP0100** | 9.03 | 68.61 | 0.00 | 0.00 | 0.00 | 22.37 |
| **RENP0108** | 24.34 | 0.00 | 0.00 | 0.00 | 0.00 | 75.66 |
| **RENP0110** | 23.35 | 0.00 | 3.66 | 0.00 | 14.75 | 58.24 |
| **RENP0112** | 14.19 | 0.00 | 0.00 | 0.00 | 22.74 | 63.07 |
| **RENP0128** | 25.23 | 0.00 | 21.77 | 1.10 | 30.19 | 21.71 |
| **RENP0132** | 18.65 | 25.10 | 0.00 | 0.00 | 0.00 | 56.26 |
| **RENP0139** | 14.51 | 0.00 | 0.00 | 0.42 | 0.00 | 85.07 |
| **RENP0144** | 14.24 | 0.00 | 34.99 | 0.00 | 6.35 | 44.42 |
| **RENP0187** | 9.35 | 0.00 | 27.80 | 0.00 | 1.36 | 61.49 |
| **RENP0192** | 4.54 | 0.00 | 13.03 | 1.34 | 1.46 | 79.64 |
| **RENP0203** | 20.20 | 16.59 | 24.59 | 0.00 | 28.23 | 10.40 |
| **RENP0228** | 16.97 | 0.00 | 8.79 | 0.00 | 3.00 | 71.24 |
| **RENP0240** | 11.27 | 0.00 | 0.00 | 0.00 | 34.72 | 54.01 |
| **RENP0251** | 19.13 | 0.00 | 10.34 | 0.00 | 8.83 | 61.70 |
| **RENP0287** | 13.28 | 0.00 | 14.15 | 0.00 | 15.80 | 56.78 |
| **RENP0368** | 7.92 | 0.00 | 1.86 | 0.00 | 0.00 | 90.22 |
| **RENP0375** | 17.37 | 45.61 | 2.08 | 0.00 | 32.77 | 2.16 |
| **RENP0443** | 13.87 | 0.00 | 24.60 | 0.00 | 0.00 | 61.53 |
| **RENP0511** | 11.33 | 0.00 | 8.01 | 0.00 | 3.13 | 77.53 |
| **RENP1524** | 7.08 | 0.00 | 0.00 | 0.00 | 0.00 | 92.92 |
| **RENP2991** | 14.49 | 0.00 | 11.86 | 0.00 | 0.00 | 70.12 |
| **RENP5612** | 5.32 | 0.00 | 9.72 | 4.40 | 4.29 | 76.27 |
| **RENP7308** | 33.21 | 0.00 | 57.56 | 0.00 | 8.46 | 0.78 |
| **RENP9611** | 14.77 | 0.00 | 5.19 | 0.00 | 18.31 | 61.73 |
| **RENP9757** | 10.01 | 0.00 | 6.41 | 3.31 | 19.60 | 30.91 |
| **RENP12892** | 27.09 | 0.00 | 0.00 | 3.22 | 68.27 | 1.42 |
| **RENP15048** | 6.63 | 0.00 | 9.00 | 5.01 | 13.51 | 63.26 |
| **RCA02** | 0.57 | 99.43 | 0.00 | 0.00 | 0.00 | 0.00 |

| | % of Woodland savanna | % of Parkland savanna | % of Grassy-woody savanna | % of Palm swamp | % of Pasture | % of Agriculture |
|---|---|---|---|---|---|---|
| | **%_Woodland** | **%_Parkland** | **%_Grassy_Woody** | **%_Palm_swamp** | **%_Pasture** | **%_Agriculture** |
| **RCA08** | 50.39 | 20.84 | 5.68 | 0.00 | 16.26 | 6.83 |
| **RCA22** | 1.89 | 98.11 | 0.00 | 0.00 | 0.00 | 0.00 |
| **RCA23** | 3.50 | 96.50 | 0.00 | 0.00 | 0.00 | 0.00 |
| **RCA30** | 2.33 | 23.34 | 0.00 | 0.00 | 23.69 | 50.64 |
| **RCA31** | 28.04 | 37.79 | 0.00 | 0.00 | 2.89 | 31.27 |
| **RCA44** | 23.63 | 0.00 | 0.00 | 0.00 | 76.37 | 0.00 |
| **RCA48** | 9.03 | 68.61 | 0.00 | 0.00 | 0.00 | 22.37 |
| **RCA49** | 6.39 | 75.54 | 0.00 | 0.00 | 0.00 | 18.07 |
| **RCA50** | 11.89 | 81.18 | 0.00 | 0.00 | 2.39 | 4.54 |
| **RCA52** | 5.43 | 93.01 | 0.00 | 0.00 | 0.00 | 1.56 |
| **RCA53** | 15.14 | 77.39 | 0.00 | 0.00 | 4.50 | 2.97 |
| **RCA57** | 1.05 | 98.95 | 0.00 | 0.00 | 0.00 | 0.00 |
| **RCA58** | 2.89 | 97.11 | 0.00 | 0.00 | 0.00 | 0.00 |
| **RCA59** | 0.66 | 99.34 | 0.00 | 0.00 | 0.00 | 0.00 |
| **RCA60** | 0.59 | 99.41 | 0.00 | 0.00 | 0.00 | 0.00 |
| **RCA62** | 4.71 | 95.29 | 0.00 | 0.00 | 0.00 | 0.00 |
| **RCA64** | 8.40 | 38.71 | 52.90 | 0.00 | 0.00 | 0.00 |
| **RCA65** | 0.00 | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **RCA66** | 13.78 | 0.00 | 5.93 | 0.00 | 66.63 | 13.66 |
| **RCA67** | 28.53 | 44.51 | 0.00 | 0.00 | 25.88 | 1.08 |
| **RCA68** | 9.81 | 89.04 | 0.00 | 0.00 | 0.00 | 1.16 |
| **RCA69** | 6.84 | 58.29 | 0.00 | 0.00 | 13.84 | 21.03 |
| **RCA70** | 13.58 | 52.65 | 32.32 | 0.00 | 0.00 | 1.44 |
| **RCA71** | 31.61 | 0.00 | 59.68 | 0.00 | 5.50 | 3.21 |
| **RCA72** | 20.20 | 16.59 | 24.59 | 0.00 | 28.23 | 10.40 |
| **RCA73** | 5.84 | 88.31 | 0.00 | 0.00 | 0.00 | 5.85 |
| **RCA74** | 10.56 | 56.83 | 0.00 | 0.00 | 12.69 | 19.91 |
| **RCA90** | 10.29 | 36.16 | 0.00 | 0.00 | 26.55 | 27.00 |

**Table 2.2.** Land use variables. Continuation.

| | % of Eucalyptus forest | % of Natural land | Distance to cities (km) | Distance to paved highways (km) | Density of homes in the basin (houses/km²) |
|---|---|---|---|---|---|
| | **%_Eucalyptus** | **%_Natural** | **City_dist** | **Highway_dist** | **House_density** |
| **TMMS0003** | 12.69 | 22.38 | 6.41 | 3.88 | 0.78 |
| **TMMS0007** | 20.32 | 43.63 | 30.04 | 1.60 | 0.18 |
| **TMMS0009** | 0.00 | 68.79 | 6.98 | 0.82 | 0.87 |
| **TMMS0027** | 34.82 | 29.64 | 34.37 | 7.21 | 0.27 |
| **TMMS0028** | 0.00 | 81.00 | 17.85 | 15.01 | 0.13 |
| **TMMS0033** | 8.33 | 50.55 | 11.61 | 3.05 | 0.00 |
| **TMMS0040** | 0.00 | 31.89 | 6.44 | 3.05 | 2.22 |
| **TMMS0043** | 17.63 | 45.06 | 34.68 | 9.25 | 0.00 |
| **TMMS0058** | 1.82 | 38.24 | 23.37 | 8.44 | 0.00 |
| **TMMS0072** | 0.00 | 51.45 | 20.42 | 20.80 | 0.11 |
| **TMMS0082** | 1.44 | 24.47 | 8.24 | 5.69 | 2.59 |
| **TMMS0088** | 0.00 | 79.43 | 27.70 | 20.53 | 0.00 |
| **TMMS0090** | 4.27 | 49.51 | 15.73 | 3.22 | 0.58 |
| **TMMS0091** | 0.98 | 48.37 | 29.61 | 3.39 | 0.28 |
| **TMMS0106** | 10.28 | 51.29 | 19.46 | 5.60 | 0.53 |
| **TMMS0119** | 12.13 | 26.29 | 7.78 | 2.00 | 0.80 |
| **TMMS0126** | 37.17 | 50.46 | 17.75 | 3.00 | 0.11 |
| **TMMS0133** | 8.50 | 25.29 | 11.60 | 6.89 | 0.75 |
| **TMMS0134** | 0.00 | 96.11 | 22.84 | 3.22 | 0.00 |
| **TMMS0137** | 0.26 | 61.56 | 3.03 | 3.61 | 0.82 |
| **TMMS0159** | 32.70 | 49.24 | 28.90 | 4.57 | 0.04 |
| **TMMS0171** | 12.51 | 61.66 | 19.25 | 0.80 | 0.39 |
| **TMMS0178** | 4.55 | 29.01 | 26.89 | 2.33 | 0.46 |
| **TMMS0183** | 22.91 | 23.25 | 15.04 | 0.85 | 0.69 |
| **TMMS0187** | 0.00 | 46.32 | 28.56 | 3.40 | 0.56 |
| **TMMS0193** | 14.83 | 14.21 | 6.65 | 2.15 | 0.72 |
| **TMMS0209** | 22.59 | 24.46 | 11.50 | 7.54 | 0.66 |
| **TMMS0214** | 10.55 | 23.91 | 15.03 | 7.38 | 0.31 |
| **TMMS0220** | 0.00 | 69.36 | 12.07 | 9.40 | 0.00 |
| **TMMS0279** | 15.04 | 32.81 | 37.83 | 4.24 | 1.16 |

| | % of Eucalyptus forest | % of Natural land | Distance to cities (km) | Distance to paved highways (km) | Density of homes in the basin (houses/km²) |
|---|---|---|---|---|---|
| | **%_Eucalyptus** | **%_Natural** | **City_dist** | **Highway_dist** | **House_density** |
| **TMMS0283** | 20.44 | 59.67 | 31.96 | 8.00 | 0.16 |
| **TMMS0290** | 0.00 | 23.17 | 2.20 | 0.85 | 1.35 |
| **TMMS0296** | 0.00 | 71.17 | 13.21 | 9.23 | 0.20 |
| **TMMS0381** | 0.25 | 47.92 | 10.36 | 2.97 | 0.85 |
| **TMMS0391** | 29.09 | 37.31 | 28.99 | 5.77 | 0.11 |
| **TMMS0437** | 0.00 | 32.78 | 2.95 | 0.57 | 0.93 |
| **TMMS1865** | 0.24 | 60.53 | 1.79 | 2.00 | 0.88 |
| **TMMS3195** | 0.00 | 56.62 | 4.94 | 0.20 | 16.52 |
| **TMMS3962** | 0.00 | 61.97 | 15.68 | 4.67 | 0.59 |
| **VGMS00002** | 0.00 | 19.23 | 9.12 | 1.08 | 0.38 |
| **VGMS00004** | 0.00 | 14.72 | 6.23 | 1.53 | 0.61 |
| **VGMS00016** | 0.00 | 12.07 | 10.74 | 1.68 | 78.73 |
| **VGMS00018** | 0.00 | 9.09 | 23.57 | 0.84 | 0.30 |
| **VGMS00022** | 0.00 | 9.68 | 16.50 | 1.38 | 0.00 |
| **VGMS00034** | 0.00 | 10.00 | 11.04 | 1.48 | 0.20 |
| **VGMS00037** | 0.00 | 9.01 | 19.03 | 0.98 | 0.27 |
| **VGMS00044** | 0.00 | 10.14 | 9.45 | 1.27 | 1.75 |
| **VGMS00048** | 0.00 | 9.84 | 19.77 | 1.15 | 0.17 |
| **VGMS00080** | 0.00 | 11.37 | 17.70 | 0.80 | 1.37 |
| **VGMS00109** | 0.00 | 12.92 | 14.36 | 4.38 | 0.33 |
| **VGMS00112** | 0.00 | 12.71 | 15.67 | 0.97 | 3.07 |
| **VGMS00121** | 0.00 | 4.71 | 15.99 | 1.15 | 0.82 |
| **VGMS00124** | 0.00 | 15.23 | 11.08 | 1.28 | 14.31 |
| **VGMS00126** | 0.00 | 18.18 | 8.81 | 1.22 | 0.45 |
| **VGMS00128** | 8.16 | 18.37 | 18.53 | 0.52 | 0.41 |
| **VGMS00162** | 0.00 | 12.14 | 13.42 | 3.80 | 1.60 |
| **VGMS00177** | 0.00 | 9.33 | 6.80 | 1.27 | 0.53 |
| **VGMS00191** | 0.00 | 10.99 | 4.15 | 1.13 | 38.57 |
| **VGMS00206** | 0.00 | 26.42 | 3.57 | 1.05 | 1.14 |
| **VGMS00210** | 0.00 | 29.84 | 15.25 | 2.77 | 0.89 |
| **VGMS00247** | 0.00 | 8.54 | 9.83 | 0.87 | 0.49 |
| **VGMS00252** | 0.00 | 12.70 | 12.16 | 1.73 | 62.55 |

| | % of Eucalyptus forest | % of Natural land | Distance to cities (km) | Distance to paved highways (km) | Density of homes in the basin (houses/km²) |
|---|---|---|---|---|---|
| | **%_Eucalyptus** | **%_Natural** | **City_dist** | **Highway_dist** | **House_density** |
| **VGMS00255** | 0.00 | 15.63 | 3.38 | 0.84 | 1.19 |
| **VGMS00277** | 0.00 | 12.70 | 12.53 | 1.77 | 59.66 |
| **VGMS00306** | 0.00 | 24.70 | 15.81 | 2.10 | 0.77 |
| **VGMS00320** | 0.00 | 14.29 | 12.02 | 1.29 | 3.66 |
| **VGMS00380** | 0.00 | 17.86 | 17.47 | 1.94 | 8.37 |
| **VGMS00387** | 0.00 | 8.07 | 6.62 | 0.92 | 0.54 |
| **VGMS00418** | 0.00 | 14.29 | 17.49 | 1.24 | 0.71 |
| **VGMS00433** | 0.00 | 11.85 | 14.75 | 1.07 | 0.64 |
| **VGMS00444** | 0.00 | 11.25 | 10.08 | 1.67 | 86.28 |
| **VGMS00447** | 0.00 | 13.56 | 2.91 | 1.15 | 5.86 |
| **VGMS00450** | 0.00 | 20.16 | 21.66 | 1.58 | 0.85 |
| **VGMS00511** | 0.00 | 16.30 | 5.29 | 0.54 | 1.25 |
| **VGMS00515** | 0.00 | 21.21 | 7.88 | 1.50 | 0.56 |
| **VGMS00558** | 0.00 | 9.09 | 1.77 | 0.55 | 95.23 |
| **VGMS00575** | 0.00 | 16.67 | 6.32 | 0.45 | 1.65 |
| **SSMS0001** | 0.00 | 5.92 | 11.17 | 0.99 | 0.90 |
| **SSMS0002** | 3.17 | 17.72 | 13.43 | 0.95 | 0.31 |
| **SSMS0008** | 0.00 | 17.47 | 16.11 | 0.93 | 0.50 |
| **SSMS0010** | 0.00 | 11.24 | 27.63 | 1.59 | 0.29 |
| **SSMS0014** | 0.00 | 5.96 | 24.09 | 1.00 | 0.11 |
| **SSMS0028** | 1.36 | 10.49 | 18.48 | 3.64 | 0.51 |
| **SSMS0029** | 0.00 | 9.27 | 20.02 | 2.37 | 0.91 |
| **SSMS0031** | 0.00 | 34.26 | 19.93 | 0.75 | 0.00 |
| **SSMS0033** | 2.86 | 26.07 | 26.88 | 9.83 | 0.44 |
| **SSMS0035** | 1.37 | 27.65 | 12.65 | 3.66 | 0.17 |
| **SSMS0037** | 0.00 | 16.63 | 18.19 | 1.67 | 0.41 |
| **SSMS0038** | 5.29 | 25.50 | 19.34 | 9.81 | 0.79 |
| **SSMS0044** | 0.00 | 12.51 | 15.80 | 1.13 | 0.60 |
| **SSMS0051** | 0.00 | 15.34 | 25.73 | 0.61 | 0.62 |
| **SSMS0053** | 0.00 | 10.52 | 24.93 | 0.63 | 0.50 |
| **SSMS0057** | 0.00 | 18.29 | 29.55 | 8.27 | 0.58 |
| **SSMS0059** | 0.00 | 30.00 | 15.52 | 6.22 | 0.00 |

| | % of Eucalyptus forest | % of Natural land | Distance to cities (km) | Distance to paved highways (km) | Density of homes in the basin (houses/km²) |
|---|---|---|---|---|---|
| | **%_Eucalyptus** | **%_Natural** | **City_dist** | **Highway_dist** | **House_density** |
| **SSMS0073** | 0.00 | 11.56 | 4.02 | 1.22 | 58.97 |
| **SSMS0078** | 1.23 | 26.37 | 14.96 | 3.02 | 0.00 |
| **SSMS0094** | 0.00 | 8.78 | 12.81 | 5.38 | 0.00 |
| **SSMS0105** | 0.00 | 14.52 | 9.41 | 2.06 | 0.31 |
| **SSMS0126** | 0.00 | 19.69 | 27.69 | 2.86 | 0.26 |
| **SSMS0129** | 5.81 | 14.87 | 23.89 | 5.79 | 0.20 |
| **SSMS0133** | 1.62 | 21.44 | 16.52 | 2.06 | 0.42 |
| **SSMS0144** | 0.00 | 13.07 | 22.63 | 3.32 | 0.29 |
| **SSMS0149** | 0.00 | 18.10 | 19.95 | 2.45 | 0.39 |
| **SSMS0150** | 3.07 | 21.38 | 14.19 | 7.80 | 0.63 |
| **SSMS0157** | 0.00 | 8.00 | 16.14 | 0.55 | 1.64 |
| **SSMS0175** | 0.00 | 29.44 | 20.62 | 4.27 | 0.90 |
| **SSMS0191** | 0.00 | 32.40 | 24.60 | 3.10 | 0.93 |
| **SSMS0193** | 5.81 | 14.87 | 0.00 | 0.00 | 0.20 |
| **SSMS0199** | 0.00 | 21.80 | 21.99 | 1.18 | 0.07 |
| **SSMS0213** | 1.42 | 13.89 | 25.01 | 3.71 | 0.52 |
| **SSMS0351** | 0.00 | 21.66 | 17.03 | 1.47 | 0.43 |
| **SSMS0408** | 0.00 | 22.70 | 5.39 | 2.88 | 0.71 |
| **SSMS0411** | 0.00 | 28.03 | 13.29 | 1.90 | 0.03 |
| **SSMS0447** | 1.18 | 22.13 | 23.33 | 3.52 | 0.63 |
| **SSMS1000** | 0.00 | 14.98 | 5.01 | 2.40 | 0.33 |
| **SSMS4173** | 0.00 | 15.48 | 1.12 | 0.18 | 732.43 |
| **SSMS4330** | 0.00 | 20.20 | 4.40 | 1.96 | 16.25 |
| **RENP0008** | 0.00 | 16.02 | 1.48 | 4.53 | 1.69 |
| **RENP0012** | 0.00 | 87.58 | 7.44 | 6.80 | 0.00 |
| **RENP0016** | 0.00 | 93.07 | 28.16 | 13.78 | 0.06 |
| **RENP0028** | 0.00 | 30.84 | 15.00 | 6.61 | 2.66 |
| **RENP0047** | 0.00 | 35.96 | 14.30 | 2.27 | 0.00 |
| **RENP0052** | 0.00 | 29.77 | 15.85 | 8.63 | 0.00 |
| **RENP0054** | 0.00 | 67.40 | 23.39 | 15.86 | 0.34 |
| **RENP0055** | 0.00 | 9.38 | 14.15 | 0.00 | 1.92 |
| **RENP0075** | 0.00 | 94.15 | 18.75 | 14.33 | 0.00 |

| | % of Eucalyptus forest | % of Natural land | Distance to cities (km) | Distance to paved highways (km) | Density of homes in the basin (houses/km²) |
|---|---|---|---|---|---|
| | **%_Eucalyptus** | **%_Natural** | **City_dist** | **Highway_dist** | **House_density** |
| **RENP0092** | 0.00 | 23.42 | 5.78 | 7.17 | 0.00 |
| **RENP0095** | 0.00 | 12.69 | 22.22 | 4.53 | 0.31 |
| **RENP0096** | 0.00 | 13.53 | 18.88 | 8.01 | 1.10 |
| **RENP0097** | 0.00 | 21.80 | 28.30 | 8.01 | 1.23 |
| **RENP0100** | 0.00 | 77.63 | 27.56 | 16.50 | 0.12 |
| **RENP0108** | 0.00 | 24.34 | 18.52 | 16.50 | 0.00 |
| **RENP0110** | 0.00 | 27.01 | 24.62 | 4.53 | 0.59 |
| **RENP0112** | 0.00 | 14.19 | 14.05 | 4.81 | 0.14 |
| **RENP0128** | 0.00 | 48.10 | 25.51 | 12.82 | 0.71 |
| **RENP0132** | 0.00 | 43.74 | 29.66 | 11.55 | 0.72 |
| **RENP0139** | 0.00 | 14.93 | 5.18 | 0.00 | 0.58 |
| **RENP0144** | 0.00 | 49.23 | 27.92 | 9.06 | 0.00 |
| **RENP0187** | 0.00 | 37.15 | 22.23 | 8.01 | 0.47 |
| **RENP0192** | 0.00 | 18.90 | 4.68 | 0.00 | 0.25 |
| **RENP0203** | 0.00 | 61.37 | 14.15 | 1.60 | 0.90 |
| **RENP0228** | 0.00 | 25.76 | 15.69 | 8.01 | 4.15 |
| **RENP0240** | 0.00 | 11.27 | 6.33 | 4.53 | 0.00 |
| **RENP0251** | 0.00 | 29.47 | 16.31 | 8.17 | 0.32 |
| **RENP0287** | 0.00 | 27.42 | 27.95 | 5.78 | 0.29 |
| **RENP0368** | 0.00 | 9.78 | 11.11 | 1.60 | 0.95 |
| **RENP0375** | 0.00 | 65.06 | 15.00 | 5.07 | 2.16 |
| **RENP0443** | 0.00 | 38.47 | 19.26 | 3.20 | 0.15 |
| **RENP0511** | 0.00 | 19.34 | 20.75 | 8.63 | 0.00 |
| **RENP1524** | 0.00 | 7.08 | 6.37 | 0.00 | 0.38 |
| **RENP2991** | 0.00 | 26.35 | 5.24 | 0.00 | 1.69 |
| **RENP5612** | 0.00 | 19.44 | 8.44 | 8.01 | 0.24 |
| **RENP7308** | 0.00 | 90.76 | 19.93 | 10.75 | 0.00 |
| **RENP9611** | 0.00 | 19.96 | 19.55 | 12.92 | 0.00 |
| **RENP9757** | 0.00 | 19.74 | 0.00 | 1.60 | 279.19 |
| **RENP12892** | 0.00 | 30.31 | 6.83 | 6.61 | 0.29 |
| **RENP15048** | 0.00 | 20.63 | 0.74 | 4.81 | 33.24 |
| **RCA02** | 0.00 | 100.00 | 19.44 | 17.12 | 0.00 |

| | % of Eucalyptus forest | % of Natural land | Distance to cities (km) | Distance to paved highways (km) | Density of homes in the basin (houses/km²) |
|---|---|---|---|---|---|
| | **%_Eucalyptus** | **%_Natural** | **City_dist** | **Highway_dist** | **House_density** |
| **RCA08** | 0.00 | 76.91 | 10.79 | 0.00 | 0.79 |
| **RCA22** | 0.00 | 100.00 | 25.58 | 11.48 | 0.00 |
| **RCA23** | 0.00 | 100.00 | 27.50 | 13.80 | 0.00 |
| **RCA30** | 0.00 | 25.67 | 24.42 | 11.48 | 0.00 |
| **RCA31** | 0.00 | 65.84 | 3.81 | 3.83 | 0.65 |
| **RCA44** | 0.00 | 23.63 | 26.96 | 3.83 | 0.00 |
| **RCA48** | 0.00 | 77.63 | 30.74 | 13.80 | 0.11 |
| **RCA49** | 0.00 | 81.93 | 30.74 | 16.24 | 1.30 |
| **RCA50** | 0.00 | 93.07 | 11.44 | 0.00 | 0.00 |
| **RCA52** | 0.00 | 98.44 | 26.96 | 12.11 | 0.51 |
| **RCA53** | 0.00 | 92.53 | 30.51 | 13.80 | 0.00 |
| **RCA57** | 0.00 | 100.00 | 19.44 | 12.11 | 0.00 |
| **RCA58** | 0.00 | 100.00 | 20.53 | 12.11 | 0.00 |
| **RCA59** | 0.00 | 100.00 | 19.44 | 13.80 | 0.00 |
| **RCA60** | 0.00 | 100.00 | 19.44 | 13.80 | 0.15 |
| **RCA62** | 0.00 | 100.00 | 13.75 | 8.56 | 0.54 |
| **RCA64** | 0.00 | 100.00 | 13.75 | 10.83 | 0.92 |
| **RCA65** | 0.00 | 100.00 | 21.57 | 8.56 | 0.00 |
| **RCA66** | 0.00 | 19.71 | 5.39 | 0.00 | 0.00 |
| **RCA67** | 0.00 | 73.03 | 7.63 | 5.41 | 0.00 |
| **RCA68** | 0.00 | 98.84 | 26.96 | 12.11 | 0.00 |
| **RCA69** | 0.00 | 65.13 | 24.12 | 7.66 | 0.00 |
| **RCA70** | 0.00 | 98.56 | 30.74 | 10.83 | 0.00 |
| **RCA71** | 0.00 | 91.29 | 19.07 | 5.41 | 0.00 |
| **RCA72** | 0.00 | 61.37 | 15.25 | 3.83 | 0.24 |
| **RCA73** | 0.00 | 94.15 | 24.12 | 7.66 | 0.37 |
| **RCA74** | 0.00 | 67.40 | 27.76 | 8.56 | 0.00 |
| **RCA90** | 0.00 | 46.46 | 23.19 | 15.78 | 0.00 |

**Table 2.3.** Hydromorphology.

| | Mean thalweg depth (cm) | Mean wetted width (m) | Mean bankfull width (m) | Mean bankfull height (m) | Mean width x mean depth ($m^2$) | Mean width/depth ratio (m/m) | Mean bank angle (degrees) | Water surface gradient over reach (%) | Channel sinuosity |
|---|---|---|---|---|---|---|---|---|---|
| | **Xdepth_T** | **Xwidth** | **XBKF_W** | **XBKF_H** | **XWXD** | **XWD_RAT** | **XBKA** | **XSLOPE_%** | **SINU** |
| **TMMS0003** | 25.673 | 1.945 | 3.855 | 0.973 | 0.499 | 7.576 | 51.864 | 0.003 | 1.253 |
| **TMMS0007** | 87.253 | 4.082 | 5.754 | 0.877 | 3.561 | 4.678 | 50.545 | 0.000 | 1.224 |
| **TMMS0009** | 29.067 | 2.535 | 9.600 | 1.109 | 0.737 | 8.721 | 26.455 | 0.003 | 1.219 |
| **TMMS0027** | 22.213 | 2.629 | 4.850 | 0.609 | 0.584 | 11.835 | 25.000 | 0.016 | 1.192 |
| **TMMS0028** | 28.020 | 4.964 | 9.285 | 1.215 | 1.391 | 17.714 | 90.000 | 0.003 | 1.293 |
| **TMMS0033** | 25.607 | 1.955 | 3.976 | 1.243 | 0.500 | 7.633 | 73.182 | 0.009 | 1.211 |
| **TMMS0040** | 14.866 | 1.470 | 4.064 | 0.936 | 0.219 | 9.888 | 33.500 | 0.024 | 1.263 |
| **TMMS0043** | 37.980 | 3.565 | 7.034 | 1.064 | 1.354 | 9.387 | 44.091 | 0.002 | 1.202 |
| **TMMS0058** | 25.667 | 4.110 | 8.955 | 1.223 | 1.055 | 16.013 | 24.727 | 0.003 | 1.339 |
| **TMMS0072** | 47.750 | 4.039 | 8.376 | 0.918 | 1.928 | 8.458 | 120.455 | 0.002 | 1.244 |
| **TMMS0082** | 41.802 | 2.993 | 4.360 | 0.580 | 1.251 | 7.159 | 46.650 | 0.001 | 1.140 |
| **TMMS0088** | 33.936 | 3.573 | 7.488 | 1.156 | 1.212 | 10.527 | 44.091 | 0.009 | 1.279 |
| **TMMS0090** | 39.527 | 2.300 | 2.864 | 0.682 | 0.909 | 5.819 | 36.364 | 0.008 | 1.243 |
| **TMMS0091** | 48.647 | 6.665 | 12.682 | 1.073 | 3.242 | 13.701 | 39.318 | 0.002 | 1.236 |
| **TMMS0106** | 40.847 | 2.425 | 6.036 | 1.950 | 0.991 | 5.937 | 76.591 | 0.003 | 1.145 |
| **TMMS0119** | 31.121 | 1.929 | 5.095 | 0.859 | 0.600 | 6.198 | 43.182 | 0.001 | 1.203 |
| **TMMS0126** | 25.007 | 1.455 | 2.389 | 0.653 | 0.364 | 5.817 | 37.045 | 0.003 | 1.238 |
| **TMMS0133** | 64.823 | 2.565 | 4.318 | 1.318 | 1.663 | 3.957 | 90.909 | 0.003 | 1.135 |
| **TMMS0134** | 35.593 | 2.328 | 3.623 | 1.116 | 0.828 | 6.539 | 55.682 | 0.019 | 1.178 |
| **TMMS0137** | 63.779 | 2.602 | 4.668 | 0.899 | 1.659 | 4.079 | 83.409 | 0.000 | 1.316 |
| **TMMS0159** | 61.133 | 10.035 | 13.300 | 0.798 | 6.135 | 16.415 | 51.000 | 0.001 | 1.390 |
| **TMMS0171** | 61.723 | 9.400 | 13.991 | 0.581 | 5.802 | 15.229 | 39.545 | 0.017 | 1.340 |
| **TMMS0178** | 33.173 | 4.343 | 7.291 | 1.468 | 1.441 | 13.092 | 44.318 | 0.002 | 1.345 |
| **TMMS0183** | 39.420 | 2.988 | 4.332 | 0.465 | 1.178 | 7.579 | 50.773 | 0.007 | 1.146 |
| **TMMS0187** | 51.073 | 4.780 | 5.800 | 0.391 | 2.441 | 9.359 | 33.636 | 0.008 | 1.195 |
| **TMMS0193** | 55.792 | 2.492 | 2.819 | 1.033 | 1.390 | 4.466 | 51.591 | 0.001 | 1.207 |
| **TMMS0209** | 73.086 | 2.553 | 3.104 | 1.224 | 1.866 | 3.493 | 41.111 | 0.004 | 1.169 |
| **TMMS0214** | 51.133 | 2.069 | 3.350 | 0.971 | 1.058 | 4.046 | 61.455 | 0.001 | 1.236 |
| **TMMS0220** | 30.327 | 4.180 | 9.605 | 1.063 | 1.268 | 13.783 | 70.455 | 0.016 | 1.313 |
| **TMMS0279** | 63.027 | 9.163 | 11.164 | 1.043 | 5.775 | 14.537 | 57.818 | 0.007 | 1.237 |
| **TMMS0283** | 28.020 | 5.329 | 12.795 | 0.735 | 1.493 | 19.018 | 23.864 | 0.012 | 1.236 |
| **TMMS0290** | 73.813 | 1.674 | 2.381 | 0.407 | 1.235 | 2.267 | 82.955 | 0.002 | 1.153 |

| | Mean thalweg depth (cm) | Mean wetted width (m) | Mean bankfull width (m) | Mean bankfull height (m) | Mean width x mean depth ($m^2$) | Mean width/depth ratio (m/m) | Mean bank angle (degrees) | Water surface gradient over reach (%) | Channel sinuosity |
|---|---|---|---|---|---|---|---|---|---|
| | **Xdepth_T** | **Xwidth** | **XBKF_W** | **XBKF_H** | **XWXD** | **XWD_RAT** | **XBKA** | **XSLOPE_%** | **SINU** |
| **TMMS0296** | 41.250 | 7.724 | 12.627 | 1.359 | 3.186 | 18.725 | 30.455 | 0.005 | 1.353 |
| **TMMS0381** | 18.960 | 0.919 | 1.481 | 0.546 | 0.174 | 4.844 | 42.273 | 0.012 | 1.182 |
| **TMMS0391** | 17.248 | 7.133 | 12.604 | 0.738 | 1.230 | 41.355 | 23.636 | 0.007 | 1.256 |
| **TMMS0437** | 42.587 | 1.464 | 2.677 | 0.584 | 0.623 | 3.438 | 48.409 | 0.005 | 1.145 |
| **TMMS1865** | 46.401 | 2.686 | 6.073 | 1.682 | 1.246 | 5.788 | 51.909 | 0.002 | 1.288 |
| **TMMS3195** | 32.827 | 1.900 | 4.091 | 0.755 | 0.624 | 5.788 | 35.909 | 0.014 | 1.266 |
| **TMMS3962** | 56.207 | 5.984 | 8.145 | 0.801 | 3.364 | 10.647 | 27.727 | 0.002 | 1.205 |
| **VGMS00002** | 24.980 | 1.000 | 0.936 | 0.286 | 0.250 | 4.003 | 25.227 | 0.008 | 1.249 |
| **VGMS00004** | 43.260 | 4.725 | 5.960 | 0.568 | 2.044 | 10.922 | 44.409 | 0.006 | 1.239 |
| **VGMS00016** | 68.245 | 5.505 | 6.609 | 0.955 | 3.757 | 8.066 | 53.864 | 0.001 | 1.281 |
| **VGMS00018** | 15.607 | 2.815 | 6.073 | 0.939 | 0.439 | 18.037 | 27.273 | 0.007 | 1.237 |
| **VGMS00022** | 18.153 | 1.961 | 4.315 | 0.668 | 0.356 | 10.803 | 30.364 | 0.015 | 1.227 |
| **VGMS00034** | 28.440 | 3.200 | 4.036 | 0.345 | 0.910 | 11.252 | 40.682 | 0.005 | 1.186 |
| **VGMS00037** | 37.286 | 1.842 | 2.538 | 0.681 | 0.687 | 4.941 | 44.688 | 0.004 | 0.921 |
| **VGMS00044** | 33.620 | 2.899 | 4.582 | 0.959 | 0.975 | 8.623 | 44.909 | 0.005 | 1.198 |
| **VGMS00048** | 58.859 | 1.825 | 3.520 | 0.550 | 1.074 | 3.101 | 57.750 | 0.008 | 1.226 |
| **VGMS00080** | 44.507 | 4.971 | 6.875 | 0.836 | 2.212 | 11.168 | 38.136 | 0.006 | 1.298 |
| **VGMS00109** | 53.173 | 2.851 | 3.956 | 0.745 | 1.516 | 5.362 | 49.909 | 0.002 | 1.293 |
| **VGMS00112** | 78.367 | 3.932 | 5.253 | 0.823 | 3.081 | 5.017 | 53.864 | 0.001 | 1.243 |
| **VGMS00121** | 32.213 | 2.957 | 5.291 | 1.478 | 0.953 | 9.179 | 88.455 | 0.004 | 1.189 |
| **VGMS00124** | 30.113 | 5.300 | 10.336 | 1.345 | 1.596 | 17.600 | 37.045 | 0.007 | 1.246 |
| **VGMS00126** | 22.527 | 3.425 | 3.857 | 0.680 | 0.771 | 15.203 | 41.591 | 0.003 | 1.172 |
| **VGMS00128** | 25.707 | 1.569 | 6.368 | 1.427 | 0.403 | 6.102 | 42.818 | 0.007 | 1.241 |
| **VGMS00162** | 45.420 | 2.533 | 3.864 | 1.191 | 1.150 | 5.576 | 65.364 | 0.005 | 1.315 |
| **VGMS00177** | 24.033 | 1.453 | 2.782 | 1.064 | 0.349 | 6.044 | 50.909 | 0.010 | 1.157 |
| **VGMS00191** | 48.420 | 4.160 | 7.155 | 1.266 | 2.014 | 8.591 | 55.318 | 0.004 | 1.209 |
| **VGMS00206** | 11.060 | 1.563 | 11.509 | 1.973 | 0.173 | 14.127 | 20.591 | 0.004 | 1.103 |
| **VGMS00210** | 26.913 | 4.085 | 8.005 | 0.999 | 1.099 | 15.178 | 35.864 | 0.004 | 1.268 |
| **VGMS00247** | 29.827 | 1.558 | 2.092 | 0.717 | 0.465 | 5.222 | 59.545 | 0.009 | 1.194 |
| **VGMS00252** | 68.973 | 5.304 | 6.659 | 1.083 | 3.658 | 7.689 | 44.591 | 0.001 | 1.143 |
| **VGMS00255** | 32.133 | 3.958 | 5.223 | 0.895 | 1.272 | 12.318 | 45.682 | 0.004 | 1.189 |
| **VGMS00277** | 69.660 | 6.845 | 7.512 | 1.070 | 4.768 | 9.826 | 43.325 | 0.001 | 1.279 |
| **VGMS00306** | 29.873 | 5.487 | 10.645 | 1.169 | 1.639 | 18.366 | 37.136 | 0.004 | 1.178 |

| | Mean thalweg depth (cm) | Mean wetted width (m) | Mean bankfull width (m) | Mean bankfull height (m) | Mean width x mean depth ($m^2$) | Mean width/depth ratio (m/m) | Mean bank angle (degrees) | Water surface gradient over reach (%) | Channel sinuosity |
|---|---|---|---|---|---|---|---|---|---|
| | **Xdepth_T** | **Xwidth** | **XBKF_W** | **XBKF_H** | **XWXD** | **XWD_RAT** | **XBKA** | **XSLOPE_%** | **SINU** |
| **VGMS00320** | 35.967 | 6.540 | 6.636 | 1.153 | 2.352 | 18.184 | 35.952 | 0.046 | 1.177 |
| **VGMS00380** | 42.367 | 4.431 | 7.009 | 0.905 | 1.877 | 10.459 | 42.500 | 0.003 | 1.252 |
| **VGMS00387** | 50.133 | 2.953 | 3.782 | 0.568 | 1.480 | 5.890 | 44.773 | 0.008 | 1.117 |
| **VGMS00418** | 31.093 | 2.265 | 5.045 | 1.136 | 0.704 | 7.285 | 46.364 | 0.013 | 1.140 |
| **VGMS00433** | 77.080 | 4.699 | 8.155 | 1.055 | 3.622 | 6.096 | 49.682 | 0.002 | 1.274 |
| **VGMS00444** | 43.633 | 7.310 | 11.873 | 0.856 | 3.190 | 16.753 | 41.409 | 0.010 | 1.205 |
| **VGMS00447** | 52.827 | 4.120 | 6.373 | 1.435 | 2.176 | 7.799 | 74.318 | 0.003 | 1.308 |
| **VGMS00450** | 33.013 | 6.129 | 11.438 | 1.027 | 2.023 | 18.565 | 32.591 | 0.003 | 1.277 |
| **VGMS00511** | 34.267 | 3.075 | 4.448 | 0.659 | 1.054 | 8.973 | 37.864 | 0.002 | 1.206 |
| **VGMS00515** | 24.393 | 4.158 | 5.889 | 1.050 | 1.014 | 17.044 | 30.682 | 0.069 | 1.245 |
| **VGMS00558** | 27.800 | 3.775 | 10.555 | 1.277 | 1.049 | 13.579 | 35.000 | 0.016 | 1.262 |
| **VGMS00575** | 33.607 | 3.479 | 5.039 | 0.642 | 1.169 | 10.352 | 34.636 | 0.007 | 1.314 |
| **SSMS0001** | 37.560 | 1.563 | 2.691 | 0.775 | 0.587 | 4.162 | 39.773 | 0.014 | 1.288 |
| **SSMS0002** | 41.080 | 5.010 | 8.368 | 2.300 | 2.058 | 12.196 | 23.409 | 0.006 | 1.374 |
| **SSMS0008** | 20.747 | 2.208 | 8.673 | 1.414 | 0.458 | 10.641 | 26.136 | 0.026 | 1.171 |
| **SSMS0010** | 82.480 | 3.401 | 6.084 | 0.605 | 2.805 | 4.123 | 40.909 | 0.002 | 1.176 |
| **SSMS0014** | 40.727 | 1.991 | 5.159 | 0.901 | 0.811 | 4.889 | 46.364 | 0.016 | 1.164 |
| **SSMS0028** | 36.100 | 2.940 | 6.255 | 0.895 | 1.061 | 8.144 | 32.773 | 0.013 | 1.179 |
| **SSMS0029** | 49.767 | 4.782 | 4.810 | 0.655 | 2.380 | 9.609 | 54.727 | 0.002 | 1.022 |
| **SSMS0031** | 25.307 | 2.179 | 5.773 | 0.595 | 0.551 | 8.610 | 27.318 | 0.011 | 1.279 |
| **SSMS0033** | 17.067 | 2.105 | 3.614 | 1.455 | 0.359 | 12.334 | 43.409 | 0.003 | 1.285 |
| **SSMS0035** | 57.167 | 6.823 | 9.809 | 1.501 | 3.901 | 11.936 | 44.545 | 0.004 | 1.182 |
| **SSMS0037** | 28.500 | 5.430 | 8.818 | 1.859 | 1.548 | 19.053 | 35.455 | 0.001 | 1.330 |
| **SSMS0038** | 45.693 | 2.490 | 5.955 | 1.277 | 1.138 | 5.449 | 45.182 | 0.003 | 1.227 |
| **SSMS0044** | 39.833 | 3.426 | 4.573 | 0.991 | 1.365 | 8.602 | 51.136 | 0.005 | 1.107 |
| **SSMS0051** | 38.040 | 1.536 | 3.273 | 0.627 | 0.584 | 4.037 | 31.773 | 0.006 | 1.320 |
| **SSMS0053** | 11.527 | 2.360 | 7.627 | 1.118 | 0.272 | 20.474 | 55.818 | 0.015 | 1.236 |
| **SSMS0057** | 54.047 | 2.953 | 4.955 | 0.936 | 1.596 | 5.463 | 67.500 | 0.008 | 1.210 |
| **SSMS0059** | 15.200 | 1.500 | 4.178 | 1.909 | 0.228 | 9.868 | 37.727 | 0.014 | 1.245 |
| **SSMS0073** | 52.867 | 4.530 | 6.473 | 1.215 | 2.395 | 8.569 | 50.727 | 0.002 | 1.218 |
| **SSMS0078** | 24.527 | 5.050 | 7.923 | 1.241 | 1.239 | 20.590 | 37.045 | 0.006 | 1.222 |
| **SSMS0094** | 27.220 | 3.333 | 5.523 | 1.341 | 0.907 | 12.243 | 41.136 | 0.013 | 1.245 |
| **SSMS0105** | 40.527 | 3.245 | 6.091 | 1.782 | 1.315 | 8.007 | 75.455 | 0.008 | 1.222 |

| | Mean thalweg depth (cm) | Mean wetted width (m) | Mean bankfull width (m) | Mean bankfull height (m) | Mean width x mean depth ($m^2$) | Mean width/depth ratio (m/m) | Mean bank angle (degrees) | Water surface gradient over reach (%) | Channel sinuosity |
|---|---|---|---|---|---|---|---|---|---|
| | **Xdepth_T** | **Xwidth** | **XBKF_W** | **XBKF_H** | **XWXD** | **XWD_RAT** | **XBKA** | **XSLOPE_%** | **SINU** |
| **SSMS0126** | 30.685 | 4.687 | 9.518 | 1.377 | 1.438 | 15.274 | 38.182 | 0.003 | 1.186 |
| **SSMS0129** | 33.867 | 3.465 | 5.699 | 0.968 | 1.173 | 10.231 | 39.091 | 0.004 | 1.128 |
| **SSMS0133** | 38.787 | 9.637 | 18.714 | 1.119 | 3.738 | 24.846 | 35.909 | 0.011 | 1.129 |
| **SSMS0144** | 17.073 | 2.414 | 5.791 | 0.929 | 0.412 | 14.138 | 39.227 | 0.006 | 1.324 |
| **SSMS0149** | 46.340 | 4.780 | 6.695 | 0.814 | 2.215 | 10.315 | 33.864 | 0.006 | 1.214 |
| **SSMS0150** | 49.247 | 3.195 | 7.091 | 1.264 | 1.573 | 6.488 | 69.545 | 0.011 | 1.208 |
| **SSMS0157** | 36.215 | 1.806 | 4.091 | 1.007 | 0.654 | 4.987 | 40.000 | 0.013 | 1.206 |
| **SSMS0175** | 25.393 | 4.590 | 8.677 | 0.955 | 1.166 | 18.076 | 28.273 | 0.019 | 1.360 |
| **SSMS0191** | 28.580 | 3.708 | 6.177 | 1.105 | 1.060 | 12.974 | 36.818 | 0.006 | 1.249 |
| **SSMS0193** | 28.707 | 3.435 | 6.764 | 1.036 | 0.986 | 11.966 | 60.000 | 0.002 | 1.291 |
| **SSMS0199** | 31.773 | 3.433 | 5.427 | 1.191 | 1.091 | 10.806 | 28.864 | 0.006 | 1.315 |
| **SSMS0213** | 68.560 | 5.240 | 9.173 | 0.988 | 3.593 | 7.643 | 47.864 | 0.011 | 1.296 |
| **SSMS0351** | 26.727 | 7.033 | 12.036 | 1.155 | 1.880 | 26.313 | 24.318 | 0.004 | 1.288 |
| **SSMS0408** | 28.613 | 1.893 | 3.045 | 1.114 | 0.542 | 6.614 | 51.136 | 0.004 | 1.261 |
| **SSMS0411** | 33.593 | 8.603 | 11.591 | 1.268 | 2.890 | 25.608 | 42.136 | 0.003 | 1.281 |
| **SSMS0447** | 27.460 | 6.974 | 9.759 | 1.182 | 1.915 | 25.396 | 34.091 | 0.004 | 1.240 |
| **SSMS1000** | 34.740 | 1.196 | 1.873 | 0.900 | 0.415 | 3.443 | 63.318 | 0.009 | 1.108 |
| **SSMS4173** | 44.507 | 8.287 | 12.827 | 1.250 | 3.688 | 18.619 | 35.227 | 0.014 | 1.270 |
| **SSMS4330** | 30.580 | 3.400 | 4.918 | 0.757 | 1.040 | 11.118 | 31.136 | 0.009 | 1.348 |
| **RENP0008** | 63.800 | 2.283 | 3.896 | 1.464 | 1.457 | 3.579 | 42.045 | 0.007 | 1.048 |
| **RENP0012** | 17.752 | 3.977 | 6.127 | 0.586 | 0.706 | 22.405 | 39.227 | 0.009 | 1.316 |
| **RENP0016** | 96.393 | 4.198 | 5.255 | 0.705 | 4.046 | 4.355 | 52.273 | 0.009 | 1.206 |
| **RENP0028** | 27.980 | 3.305 | 4.914 | 1.205 | 0.925 | 11.812 | 25.409 | 0.019 | 1.280 |
| **RENP0047** | 13.800 | 1.812 | 3.509 | 0.764 | 0.250 | 13.127 | 30.000 | 0.014 | 1.190 |
| **RENP0052** | 20.660 | 2.484 | 5.359 | 0.795 | 0.513 | 12.023 | 18.273 | 0.008 | 1.299 |
| **RENP0054** | 14.247 | 0.815 | 1.950 | 0.691 | 0.116 | 5.721 | 27.273 | 0.048 | 1.184 |
| **RENP0055** | 28.653 | 1.925 | 3.264 | 1.109 | 0.552 | 6.718 | 50.000 | 0.009 | 1.243 |
| **RENP0075** | 46.287 | 4.323 | 12.227 | 0.805 | 2.001 | 9.339 | 35.227 | 0.005 | 1.148 |
| **RENP0092** | 7.013 | 1.533 | 3.791 | 0.477 | 0.107 | 21.851 | 37.500 | 0.006 | 1.153 |
| **RENP0095** | 41.087 | 1.282 | 2.132 | 0.632 | 0.527 | 3.119 | 38.409 | 0.023 | 1.174 |
| **RENP0096** | 27.407 | 2.500 | 4.445 | 1.100 | 0.685 | 9.122 | 33.636 | 0.006 | 1.189 |
| **RENP0097** | 21.727 | 3.135 | 5.591 | 0.968 | 0.681 | 14.430 | 57.955 | 0.014 | 1.227 |
| **RENP100** | 34.727 | 2.890 | 4.359 | 0.845 | 1.004 | 8.322 | 33.182 | 0.005 | 1.212 |

| | Mean thalweg depth (cm) | Mean wetted width (m) | Mean bankfull width (m) | Mean bankfull height (m) | Mean width x mean depth ($m^2$) | Mean width/depth ratio (m/m) | Mean bank angle (degrees) | Water surface gradient over reach (%) | Channel sinuosity |
|---|---|---|---|---|---|---|---|---|---|
| | **Xdepth_T** | **Xwidth** | **XBKF_W** | **XBKF_H** | **XWXD** | **XWD_RAT** | **XBKA** | **XSLOPE_%** | **SINU** |
| **RENP0108** | 14.460 | 2.111 | 4.691 | 1.055 | 0.305 | 14.599 | 28.864 | 0.020 | 1.263 |
| **RENP0110** | 25.687 | 2.188 | 2.645 | 0.845 | 0.562 | 8.516 | 67.273 | 0.018 | 1.195 |
| **RENP0112** | 17.820 | 2.759 | 3.718 | 0.886 | 0.492 | 15.480 | 45.909 | 0.006 | 1.072 |
| **RENP0128** | 41.787 | 1.525 | 3.391 | 0.927 | 0.637 | 3.649 | 29.455 | 0.004 | 1.147 |
| **RENP0132** | 21.580 | 1.824 | 4.691 | 0.950 | 0.394 | 8.451 | 32.455 | 0.013 | 1.040 |
| **RENP0139** | 22.480 | 2.425 | 4.500 | 0.964 | 0.545 | 10.787 | 29.955 | 0.004 | 1.162 |
| **RENP0144** | 41.747 | 3.398 | 6.368 | 0.927 | 1.418 | 8.138 | 30.318 | 0.005 | 1.258 |
| **RENP0187** | 17.053 | 2.223 | 4.659 | 0.886 | 0.379 | 13.033 | 21.545 | 0.003 | 1.285 |
| **RENP0192** | 30.667 | 1.915 | 2.909 | 1.173 | 0.587 | 6.245 | 48.182 | 0.005 | 1.006 |
| **RENP0203** | 31.487 | 3.685 | 7.355 | 1.136 | 1.160 | 11.703 | 20.682 | 0.005 | 1.189 |
| **RENP0228** | 23.027 | 2.164 | 3.205 | 0.836 | 0.498 | 9.396 | 39.762 | 0.020 | 1.160 |
| **RENP0240** | 16.567 | 1.715 | 7.682 | 0.735 | 0.284 | 10.352 | 24.318 | 0.007 | 1.078 |
| **RENP0251** | 19.500 | 3.180 | 4.316 | 0.700 | 0.620 | 16.308 | 41.818 | 0.017 | 1.233 |
| **RENP0287** | 20.027 | 1.327 | 4.164 | 0.641 | 0.266 | 6.626 | 25.682 | 0.014 | 1.059 |
| **RENP0368** | 18.567 | 2.640 | 4.818 | 1.214 | 0.490 | 14.219 | 39.545 | 0.013 | 1.134 |
| **RENP0375** | 48.587 | 5.780 | 9.511 | 1.732 | 2.808 | 11.896 | 45.909 | 0.005 | 1.230 |
| **RENP0443** | 24.107 | 2.616 | 3.614 | 0.800 | 0.631 | 10.850 | 48.636 | 0.003 | 1.280 |
| **RENP0511** | 35.513 | 4.570 | 7.518 | 0.655 | 1.623 | 12.868 | 35.227 | 0.005 | 1.307 |
| **RENP1524** | 22.153 | 1.883 | 4.491 | 1.018 | 0.417 | 8.498 | 32.857 | 0.023 | 1.253 |
| **RENP2991** | 22.207 | 2.515 | 5.064 | 0.864 | 0.558 | 11.325 | 22.273 | 0.010 | 1.248 |
| **RENP5612** | 37.820 | 2.040 | 2.982 | 0.891 | 0.772 | 5.394 | 62.143 | 0.003 | 1.154 |
| **RENP7308** | 18.307 | 1.855 | 5.491 | 0.723 | 0.340 | 10.133 | 38.409 | 0.013 | 1.222 |
| **RENP9611** | 15.693 | 3.882 | 4.036 | 0.745 | 0.609 | 24.735 | 39.773 | 0.017 | 0.904 |
| **RENP9757** | 13.327 | 2.277 | 3.741 | 0.842 | 0.303 | 17.088 | 51.818 | 0.008 | 1.295 |
| **RENP12892** | 31.527 | 1.440 | 4.250 | 0.805 | 0.454 | 4.568 | 26.455 | 0.013 | 1.212 |
| **RENP15048** | 54.040 | 1.116 | 2.336 | 0.618 | 0.603 | 2.065 | 58.864 | 0.010 | 1.292 |
| **RCA02** | 48.000 | 4.089 | 9.833 | 0.633 | 1.963 | 8.518 | 24.250 | 0.062 | 0.655 |
| **RCA08** | 16.100 | 1.735 | 3.417 | 1.400 | 0.279 | 10.776 | 32.500 | 0.045 | 0.613 |
| **RCA22** | 52.160 | 6.800 | 8.500 | 0.700 | 3.547 | 13.037 | 31.917 | 0.014 | 0.679 |
| **RCA23** | 24.000 | 2.045 | 6.333 | 0.800 | 0.491 | 8.521 | 36.667 | 0.063 | 0.625 |
| **RCA30** | 77.400 | 65.878 | 8.000 | 1.500 | 50.990 | 85.114 | 50.333 | 0.033 | 0.630 |
| **RCA31** | 18.400 | 2.880 | 7.500 | 1.250 | 0.530 | 15.652 | 56.667 | 0.016 | 0.659 |
| **RCA44** | 12.133 | 0.835 | 3.217 | 1.417 | 0.101 | 6.882 | 54.167 | 0.018 | 0.700 |

| | Mean thalweg depth (cm) | Mean wetted width (m) | Mean bankfull width (m) | Mean bankfull height (m) | Mean width x mean depth ($m^2$) | Mean width/depth ratio (m/m) | Mean bank angle (degrees) | Water surface gradient over reach (%) | Channel sinuosity |
|---|---|---|---|---|---|---|---|---|---|
| | **Xdepth_T** | **Xwidth** | **XBKF_W** | **XBKF_H** | **XWXD** | **XWD_RAT** | **XBKA** | **XSLOPE_%** | **SINU** |
| **RCA48** | 19.100 | 3.135 | 4.250 | 0.867 | 0.599 | 16.414 | 35.000 | 0.012 | 0.578 |
| **RCA49** | 39.167 | 3.060 | 4.333 | 0.900 | 1.199 | 7.813 | 32.500 | 0.008 | 0.622 |
| **RCA50** | 67.867 | 6.310 | 5.567 | 2.250 | 4.282 | 9.298 | 24.583 | 0.001 | 0.688 |
| **RCA52** | 14.167 | 7.520 | 7.933 | 1.117 | 1.065 | 53.082 | 54.583 | 0.004 | 0.629 |
| **RCA53** | 23.100 | 3.290 | 7.167 | 2.250 | 0.760 | 14.242 | 34.583 | 0.022 | 0.589 |
| **RCA57** | 76.920 | 3.260 | 4.500 | 1.517 | 2.508 | 4.238 | 62.083 | 0.004 | 0.611 |
| **RCA58** | 27.960 | 1.690 | 7.167 | 1.000 | 0.473 | 6.044 | 60.167 | 0.046 | 0.628 |
| **RCA59** | 23.960 | 4.660 | 6.917 | 1.300 | 1.117 | 19.449 | 49.333 | 0.072 | 0.675 |
| **RCA60** | 20.040 | 4.255 | 7.833 | 2.383 | 0.853 | 21.233 | 44.000 | 0.178 | 0.660 |
| **RCA62** | 23.800 | 0.661 | 4.833 | 1.000 | 0.157 | 2.777 | 20.417 | 0.173 | 0.657 |
| **RCA64** | 19.760 | 1.054 | 2.417 | 3.750 | 0.208 | 5.334 | 36.667 | 0.112 | 0.590 |
| **RCA65** | 7.733 | 1.160 | 5.000 | 1.800 | 0.090 | 15.000 | 54.167 | 0.014 | 0.666 |
| **RCA66** | 15.433 | 1.610 | 6.667 | 2.000 | 0.248 | 10.432 | 55.417 | 0.013 | 0.650 |
| **RCA67** | 17.933 | 2.055 | 6.167 | 1.283 | 0.369 | 11.459 | 50.000 | 0.014 | 0.619 |
| **RCA68** | 25.500 | 1.730 | 3.667 | 1.500 | 0.441 | 6.784 | 52.500 | 0.020 | 0.657 |
| **RCA69** | 22.533 | 2.765 | 4.733 | 1.100 | 0.623 | 12.271 | 47.500 | 0.019 | 0.592 |
| **RCA70** | 42.067 | 1.825 | 3.583 | 0.733 | 0.768 | 4.338 | 47.917 | 0.027 | 0.623 |
| **RCA71** | 19.367 | 1.778 | 3.833 | 1.450 | 0.344 | 9.180 | 35.833 | 0.018 | 0.630 |
| **RCA72** | 14.533 | 4.664 | 7.385 | 1.692 | 0.678 | 32.089 | 44.583 | 0.003 | 0.664 |
| **RCA73** | 13.667 | 5.475 | 8.167 | 1.917 | 0.748 | 40.061 | 39.583 | 0.007 | 0.548 |
| **RCA74** | 44.833 | 6.790 | 8.667 | 1.683 | 3.044 | 15.145 | 42.917 | 0.008 | 0.613 |
| **RCA90** | 33.633 | 4.805 | 6.500 | 1.233 | 1.616 | 14.286 | 41.250 | 0.001 | 0.697 |

**Table 2.4.** Substrate.

| | Mean embeddedness (%) | % of bedrock (>4000 mm) | % of boulders (250 to 4000 mm) | % of cobble (64 to 250mm) | % of coarse gravel (16 to 64 mm) | % of fine gravel (2 to 16mm) | % of sand (0.6 to2 mm) | % of fines (<0.6 mm) | Total Organic matter (%) | % of Wood | Log10 estimated geometric mean substrate diameter (mm) | Log10 - Relative Bed Stability (dimensionless: m/m)) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **XEMBED** | **PCT_BDRK** | **PCT_BL** | **PCT_CB** | **PCT_GC** | **PCT_GF** | **PCT_SA** | **PCT_FN** | **PCT_ORG** | **PCT_WD** | **LSUB_DMM** | **LRBS** |
| **TMMS0003** | 44.182 | 0.000 | 0.000 | 0.000 | 0.000 | 26.667 | 20.952 | 9.524 | 40.000 | 9.524 | -0.161 | -1.440 |
| **TMMS0007** | 72.549 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 10.476 | 56.190 | 33.333 | 13.333 | -1.852 | -1.787 |
| **TMMS0009** | 61.273 | 0.000 | 11.429 | 0.000 | 7.619 | 64.762 | 5.714 | 10.476 | 0.000 | 0.000 | 0.697 | -0.674 |
| **TMMS0027** | 49.455 | 0.000 | 22.857 | 43.810 | 5.714 | 0.000 | 0.000 | 19.048 | 5.714 | 0.000 | 1.369 | -0.495 |
| **TMMS0028** | 34.000 | 10.476 | 2.857 | 17.143 | 7.619 | 37.143 | 8.571 | 8.571 | 7.619 | 0.000 | 1.097 | -0.277 |
| **TMMS0033** | 19.455 | 28.571 | 20.000 | 8.571 | 4.762 | 21.905 | 12.381 | 1.905 | 1.905 | 0.000 | 2.030 | 0.151 |
| **TMMS0040** | 50.364 | 0.000 | 28.571 | 40.000 | 2.857 | 12.381 | 15.238 | 0.952 | 0.000 | 0.000 | 1.744 | -0.467 |
| **TMMS0043** | 61.091 | 0.000 | 50.476 | 4.762 | 0.000 | 2.857 | 40.000 | 0.000 | 1.905 | 0.952 | 1.480 | 0.387 |
| **TMMS0058** | 30.909 | 56.190 | 0.000 | 0.000 | 0.952 | 0.000 | 18.095 | 3.810 | 20.952 | 0.000 | 2.479 | 1.024 |
| **TMMS0072** | 30.962 | 18.095 | 10.476 | 11.429 | 5.714 | 5.714 | 29.524 | 6.667 | 12.381 | 0.000 | 1.239 | 0.077 |
| **TMMS0082** | 79.800 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 6.000 | 94.000 | 0.000 | -2.111 | -2.778 |
| **TMMS0088** | 21.633 | 47.619 | 20.000 | 1.905 | 0.000 | 10.476 | 8.571 | 8.571 | 2.857 | 0.000 | 2.353 | 0.432 |
| **TMMS0090** | 26.111 | 0.000 | 59.048 | 40.952 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 2.632 | 1.004 |
| **TMMS0091** | 71.782 | 7.619 | 20.952 | 19.048 | 2.857 | 7.619 | 31.429 | 7.619 | 1.905 | 0.000 | 1.131 | -0.166 |
| **TMMS0106** | 81.818 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 81.905 | 14.286 | 0.952 | -2.017 | -3.533 |
| **TMMS0119** | 62.545 | 0.000 | 0.000 | 1.000 | 0.000 | 0.000 | 0.000 | 59.000 | 40.000 | 2.000 | -2.041 | -2.806 |
| **TMMS0126** | 57.818 | 0.952 | 0.000 | 4.762 | 4.762 | 0.000 | 16.190 | 20.952 | 31.429 | 0.952 | -0.451 | -1.426 |
| **TMMS0133** | 90.909 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 92.381 | 7.619 | 1.905 | -2.111 | -3.561 |
| **TMMS0134** | 40.182 | 4.762 | 13.333 | 28.571 | 0.000 | 0.000 | 5.714 | 12.381 | 13.333 | 0.000 | 1.029 | -1.162 |
| **TMMS0137** | 83.091 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 83.810 | 16.190 | 10.476 | -2.111 | -2.557 |
| **TMMS0159** | 70.577 | 1.923 | 31.731 | 6.731 | 5.769 | 0.962 | 41.346 | 1.923 | 9.615 | 0.000 | 1.138 | 0.156 |
| **TMMS0171** | 54.727 | 21.905 | 60.000 | 2.857 | 0.000 | 0.000 | 0.000 | 15.238 | 0.000 | 0.000 | 2.360 | 0.328 |
| **TMMS0178** | 47.455 | 9.524 | 5.714 | 19.048 | 19.048 | 5.714 | 13.333 | 16.190 | 10.476 | 1.905 | 0.956 | -0.378 |
| **TMMS0183** | 64.727 | 5.714 | 11.429 | 25.714 | 0.000 | 0.000 | 0.000 | 40.952 | 13.333 | 0.000 | 0.269 | -1.192 |
| **TMMS0187** | 45.091 | 43.810 | 6.667 | 0.000 | 0.000 | 0.000 | 1.905 | 38.095 | 9.524 | 0.000 | 1.140 | -0.342 |
| **TMMS0193** | 96.364 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 85.714 | 14.286 | 9.524 | -2.111 | -3.121 |
| **TMMS0209** | 97.600 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 58.824 | 41.176 | 0.000 | -2.111 | -3.505 |
| **TMMS0214** | 91.636 | 0.000 | 0.000 | 1.905 | 0.000 | 0.000 | 7.619 | 67.619 | 21.905 | 0.000 | -1.821 | -2.765 |
| **TMMS0220** | 26.545 | 37.143 | 11.429 | 4.762 | 7.619 | 13.333 | 4.762 | 8.571 | 12.381 | 0.000 | 2.110 | 0.019 |
| **TMMS0279** | 18.455 | 60.952 | 13.333 | 6.667 | 0.000 | 0.000 | 0.000 | 15.238 | 2.857 | 0.000 | 2.579 | 0.805 |

| | Mean embeddedness (%) | % of bedrock (>4000 mm) | % of boulders (250 to 4000 mm) | % of cobble (64 to 250mm) | % of coarse gravel (16 to 64 mm) | % of fine gravel (2 to 16mm) | % of sand (0.6 to2 mm) | % of fines (<0.6 mm) | Total Organic matter (%) | % of Wood | Log10 estimated geometric mean substrate diameter (mm) | Log10 - Relative Bed Stability (dimensionless: m/m)) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **XEMBED** | **PCT_BDRK** | **PCT_BL** | **PCT_CB** | **PCT_GC** | **PCT_GF** | **PCT_SA** | **PCT_FN** | **PCT_ORG** | **PCT_WD** | **LSUB_DMM** | **LRBS** |
| **TMMS0283** | 22.909 | 50.000 | 32.692 | 9.615 | 0.000 | 0.000 | 7.692 | 0.000 | 0.000 | 0.000 | 3.024 | 1.163 |
| **TMMS0290** | 100.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 100.000 | 0.000 | 0.000 | -2.111 | -2.995 |
| **TMMS0296** | 34.818 | 15.238 | 13.333 | 34.286 | 9.524 | 5.714 | 0.000 | 14.286 | 7.619 | 0.000 | 1.707 | -0.019 |
| **TMMS0381** | 61.818 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 59.048 | 40.952 | 4.762 | -2.111 | -3.801 |
| **TMMS0391** | 51.818 | 80.952 | 13.333 | 5.714 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 3.558 | 1.985 |
| **TMMS0437** | 94.182 | 0.000 | 0.000 | 0.000 | 2.857 | 7.619 | 0.000 | 82.857 | 6.667 | 0.000 | -1.766 | -3.145 |
| **TMMS1865** | 81.818 | 0.000 | 0.000 | 0.000 | 4.000 | 2.000 | 0.000 | 78.000 | 16.000 | 2.000 | -1.871 | -3.302 |
| **TMMS3195** | 87.273 | 12.381 | 1.905 | 0.000 | 0.000 | 0.000 | 0.000 | 85.714 | 0.000 | 0.000 | -1.288 | -3.187 |
| **TMMS3962** | 39.245 | 0.000 | 2.083 | 14.583 | 20.833 | 5.208 | 6.250 | 4.167 | 14.583 | 0.000 | 0.708 | -0.463 |
| **VGMS00002** | 94.545 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 42.857 | 57.143 | 0.000 | -2.111 | -3.302 |
| **VGMS00004** | 44.909 | 2.857 | 0.000 | 3.810 | 27.619 | 4.762 | 12.381 | 20.952 | 26.667 | 1.905 | 0.190 | -1.288 |
| **VGMS00016** | 81.455 | 0.000 | 1.905 | 0.952 | 1.905 | 21.905 | 22.857 | 41.905 | 8.571 | 0.952 | -0.787 | -1.593 |
| **VGMS00018** | 63.455 | 24.762 | 10.476 | 10.476 | 0.952 | 0.000 | 0.000 | 34.286 | 19.048 | 0.000 | 0.932 | -0.728 |
| **VGMS00022** | 40.727 | 23.810 | 4.762 | 12.381 | 1.905 | 6.667 | 14.286 | 6.667 | 26.667 | 0.000 | 1.594 | -0.243 |
| **VGMS00034** | 64.909 | 0.000 | 35.238 | 17.143 | 0.000 | 0.000 | 0.000 | 32.381 | 15.238 | 0.000 | 0.866 | -0.304 |
| **VGMS00037** | 96.250 | 0.000 | 0.000 | 0.000 | 0.000 | 5.333 | 18.667 | 74.667 | 1.333 | 0.000 | -1.644 | -2.738 |
| **VGMS00044** | 65.455 | 0.000 | 0.000 | 0.000 | 0.952 | 28.571 | 6.667 | 15.238 | 47.619 | 7.619 | -0.235 | -1.846 |
| **VGMS00048** | 68.400 | 0.000 | 0.000 | 20.000 | 0.000 | 5.263 | 4.211 | 50.526 | 20.000 | 0.000 | -0.782 | -2.447 |
| **VGMS00080** | 37.273 | 15.238 | 18.095 | 15.238 | 8.571 | 9.524 | 3.810 | 17.143 | 6.667 | 0.000 | 1.346 | -0.290 |
| **VGMS00109** | 56.364 | 0.000 | 0.000 | 0.000 | 0.000 | 36.190 | 4.762 | 15.238 | 41.905 | 16.190 | -0.123 | -1.218 |
| **VGMS00112** | 66.364 | 0.000 | 0.000 | 10.476 | 1.905 | 16.190 | 23.810 | 33.333 | 11.429 | 2.857 | -0.500 | -1.560 |
| **VGMS00121** | 74.727 | 0.000 | 8.571 | 0.952 | 16.190 | 14.286 | 48.571 | 7.619 | 0.000 | 0.000 | 0.244 | -1.408 |
| **VGMS00124** | 54.364 | 36.190 | 16.190 | 10.476 | 0.000 | 0.000 | 19.048 | 8.571 | 9.524 | 0.000 | 1.984 | 0.154 |
| **VGMS00126** | 63.273 | 0.952 | 6.667 | 5.714 | 5.714 | 7.619 | 19.048 | 36.190 | 15.238 | 0.000 | -0.416 | -1.682 |
| **VGMS00128** | 69.455 | 0.000 | 3.810 | 0.000 | 0.000 | 24.762 | 4.762 | 60.000 | 0.952 | 0.000 | -0.997 | -2.855 |
| **VGMS00162** | 68.182 | 0.000 | 9.524 | 1.905 | 0.000 | 30.476 | 4.762 | 31.429 | 11.429 | 3.810 | -0.147 | -1.850 |
| **VGMS00177** | | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 89.524 | 0.952 | 0.952 | -1.908 | -3.803 |
| **VGMS00191** | 67.636 | 0.000 | 0.952 | 3.810 | 8.571 | 22.857 | 4.762 | 41.905 | 16.190 | 5.714 | -0.593 | -2.222 |
| **VGMS00206** | 76.111 | 0.000 | 1.905 | 20.000 | 0.000 | 15.238 | 58.095 | 4.762 | 0.000 | 0.000 | 0.224 | -1.508 |
| **VGMS00210** | 57.636 | 0.000 | 4.762 | 19.048 | 40.000 | 16.190 | 10.476 | 0.000 | 6.667 | 0.000 | 1.306 | -0.172 |
| **VGMS00247** | 58.182 | 0.000 | 0.000 | 0.000 | 3.810 | 20.000 | 14.286 | 34.286 | 27.619 | 0.952 | -0.804 | -2.539 |

| | Mean embeddedness (%) | % of bedrock (>4000 mm) | % of boulders (250 to 4000 mm) | % of cobble (64 to 250mm) | % of coarse gravel (16 to 64 mm) | % of fine gravel (2 to 16mm) | % of sand (0.6 to2 mm) | % of fines (<0.6 mm) | Total Organic matter (%) | % of Wood | Log10 estimated geometric mean substrate diameter (mm) | Log10 - Relative Bed Stability (dimensionless: m/m)) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **XEMBED** | **PCT_BDRK** | **PCT_BL** | **PCT_CB** | **PCT_GC** | **PCT_GF** | **PCT_SA** | **PCT_FN** | **PCT_ORG** | **PCT_WD** | **LSUB_DMM** | **LRBS** |
| **VGMS00252** | 59.909 | 0.000 | 1.905 | 2.857 | 0.952 | 40.952 | 18.095 | 0.000 | 15.238 | 0.952 | 0.420 | -0.599 |
| **VGMS00255** | 63.091 | 0.000 | 23.000 | 2.000 | 2.000 | 13.000 | 14.000 | 39.000 | 7.000 | 0.000 | -0.030 | -1.559 |
| **VGMS00277** | 66.007 | 0.952 | 18.095 | 1.905 | 3.810 | 4.762 | 17.143 | 40.952 | 12.381 | 0.000 | -0.264 | -1.327 |
| **VGMS00306** | 66.818 | 0.000 | 15.238 | 40.000 | 22.857 | 5.714 | 11.429 | 0.000 | 4.762 | 0.000 | 1.714 | 0.147 |
| **VGMS00320** | 48.800 | 35.106 | 3.191 | 23.404 | 8.511 | 6.383 | 20.213 | 3.191 | 0.000 | 0.000 | 1.921 | -0.681 |
| **VGMS00380** | 63.636 | 0.000 | 0.000 | 0.000 | 0.000 | 40.000 | 23.810 | 28.571 | 7.619 | 0.000 | -0.446 | -1.840 |
| **VGMS00387** | 67.045 | 28.571 | 0.000 | 0.000 | 0.000 | 0.000 | 0.952 | 53.333 | 17.143 | 7.619 | -0.070 | -1.748 |
| **VGMS00418** | 54.364 | 0.000 | 1.905 | 29.524 | 3.810 | 12.381 | 8.571 | 25.714 | 18.095 | 0.952 | 0.300 | -1.733 |
| **VGMS00433** | 63.636 | 0.000 | 8.081 | 2.020 | 0.000 | 0.000 | 4.040 | 50.505 | 2.020 | 0.000 | -0.816 | -2.140 |
| **VGMS00444** | 42.909 | 0.000 | 3.810 | 30.476 | 17.143 | 22.857 | 14.286 | 4.762 | 6.667 | 1.905 | 1.091 | -0.784 |
| **VGMS00447** | 96.667 | 0.000 | 3.774 | 0.000 | 0.000 | 3.774 | 34.906 | 57.547 | 0.000 | 0.000 | -1.234 | -2.729 |
| **VGMS00450** | 94.364 | 86.667 | 0.000 | 0.000 | 0.000 | 4.762 | 5.714 | 0.000 | 1.905 | 0.000 | 3.325 | 2.021 |
| **VGMS00511** | 62.000 | 0.000 | 1.887 | 5.660 | 0.943 | 26.415 | 16.981 | 31.132 | 9.434 | 0.000 | -0.383 | -1.473 |
| **VGMS00515** | 47.451 | 42.453 | 8.491 | 18.868 | 1.887 | 2.830 | 25.472 | 0.000 | 0.000 | 0.000 | 2.177 | -0.558 |
| **VGMS00558** | 59.636 | 18.868 | 16.981 | 48.113 | 1.887 | 0.943 | 4.717 | 0.000 | 8.491 | 0.000 | 2.451 | 0.323 |
| **VGMS00575** | 53.273 | 0.000 | 13.684 | 25.263 | 3.158 | 11.579 | 16.842 | 13.684 | 12.632 | 0.000 | 0.812 | -0.772 |
| **SSMS0001** | 67.818 | 0.000 | 2.857 | 8.571 | 7.619 | 2.857 | 49.524 | 0.952 | 26.667 | 4.762 | 0.210 | -1.554 |
| **SSMS0002** | 13.091 | 51.429 | 0.000 | 5.714 | 9.524 | 13.333 | 19.048 | 0.000 | 0.952 | 0.000 | 2.227 | 0.228 |
| **SSMS0008** | 40.545 | 36.190 | 0.000 | 11.429 | 0.000 | 0.000 | 5.714 | 19.048 | 27.619 | 0.000 | 1.616 | -0.824 |
| **SSMS0010** | 77.909 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 52.703 | 41.892 | 5.405 | 0.000 | -1.191 | -2.408 |
| **SSMS0014** | 20.000 | 0.000 | 1.923 | 16.346 | 14.423 | 11.538 | 0.000 | 16.346 | 33.654 | 0.962 | 0.543 | -1.535 |
| **SSMS0028** | 51.273 | 0.000 | 0.000 | 14.423 | 12.500 | 16.346 | 1.923 | 21.154 | 32.692 | 0.000 | 0.236 | -1.748 |
| **SSMS0029** | 48.000 | 0.000 | 16.190 | 2.857 | 1.905 | 37.143 | 3.810 | 31.429 | 6.667 | 0.000 | 0.185 | -0.816 |
| **SSMS0031** | 67.273 | 0.000 | 0.000 | 0.000 | 0.000 | 1.000 | 6.000 | 41.000 | 52.000 | 0.000 | -1.845 | -3.586 |
| **SSMS0033** | 84.455 | 0.000 | 0.952 | 0.000 | 18.095 | 18.095 | 41.905 | 20.952 | 0.000 | 0.000 | -0.198 | -1.676 |
| **SSMS0035** | 55.545 | 0.000 | 27.619 | 19.048 | 3.810 | 0.952 | 33.333 | 0.000 | 12.381 | 0.000 | 1.301 | -0.369 |
| **SSMS0037** | 63.091 | 0.000 | 0.000 | 0.000 | 2.000 | 16.000 | 38.000 | 9.000 | 23.000 | 0.000 | -0.278 | -1.122 |
| **SSMS0038** | 67.455 | 4.762 | 0.000 | 1.905 | 0.000 | 6.667 | 45.714 | 11.429 | 27.619 | 4.762 | -0.253 | -1.721 |
| **SSMS0044** | 52.909 | 5.769 | 6.731 | 3.846 | 6.731 | 22.115 | 0.962 | 18.269 | 26.923 | 0.962 | 0.516 | -1.068 |
| **SSMS0051** | 45.818 | 0.000 | 0.000 | 0.000 | 2.885 | 17.308 | 0.000 | 13.462 | 66.346 | 9.615 | -0.328 | -1.791 |
| **SSMS0053** | 82.545 | 11.000 | 1.000 | 1.000 | 0.000 | 0.000 | 0.000 | 65.000 | 22.000 | 1.000 | -1.164 | -3.224 |

| | Mean embeddedness (%) | % of bedrock (>4000 mm) | % of boulders (250 to 4000 mm) | % of cobble (64 to 250mm) | % of coarse gravel (16 to 64 mm) | % of fine gravel (2 to 16mm) | % of sand (0.6 to2 mm) | % of fines (<0.6 mm) | Total Organic matter (%) | % of Wood | Log10 estimated geometric mean substrate diameter (mm) | Log10 - Relative Bed Stability (dimensionless: m/m)) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **XEMBED** | **PCT_BDRK** | **PCT_BL** | **PCT_CB** | **PCT_GC** | **PCT_GF** | **PCT_SA** | **PCT_FN** | **PCT_ORG** | **PCT_WD** | **LSUB_DMM** | **LRBS** |
| **SSMS0057** | 74.727 | 0.000 | 0.952 | 0.952 | 0.952 | 1.905 | 1.905 | 58.095 | 35.238 | 1.905 | -1.788 | -3.571 |
| **SSMS0059** | 84.182 | 0.000 | 0.000 | 0.000 | 0.952 | 3.810 | 67.619 | 0.952 | 24.762 | 3.810 | -0.383 | -2.632 |
| **SSMS0073** | 44.545 | 8.571 | 1.905 | 3.810 | 1.905 | 29.524 | 14.286 | 16.190 | 12.381 | 0.952 | 0.345 | -0.921 |
| **SSMS0078** | 76.727 | 1.905 | 5.714 | 4.762 | 2.857 | 14.286 | 65.714 | 1.905 | 1.905 | 0.000 | 0.154 | -1.616 |
| **SSMS0094** | 58.636 | 0.000 | 1.905 | 14.286 | 18.095 | 20.952 | 34.286 | 0.000 | 9.524 | 0.000 | 0.696 | -1.416 |
| **SSMS0105** | 78.000 | 0.000 | 12.500 | 8.654 | 6.731 | 6.731 | 1.923 | 33.654 | 6.731 | 0.962 | -0.011 | -2.073 |
| **SSMS0126** | 95.091 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 76.190 | 0.952 | 20.000 | 5.714 | -0.464 | -1.945 |
| **SSMS0129** | 97.818 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 90.476 | 3.810 | 5.714 | 0.000 | -0.527 | -1.998 |
| **SSMS0133** | 70.636 | 7.619 | 18.095 | 1.905 | 9.524 | 0.952 | 60.000 | 0.000 | 0.952 | 0.000 | 0.750 | -1.245 |
| **SSMS0144** | 22.364 | 60.952 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 10.476 | 28.571 | 0.000 | 2.893 | 1.369 |
| **SSMS0149** | 68.909 | 0.000 | 12.381 | 3.810 | 12.381 | 1.905 | 0.952 | 68.571 | 0.000 | 0.000 | -0.800 | -2.379 |
| **SSMS0150** | 61.636 | 0.000 | 2.857 | 16.190 | 24.762 | 14.286 | 0.000 | 24.762 | 11.429 | 0.000 | 0.433 | -1.631 |
| **SSMS0157** | 30.000 | 0.000 | 0.000 | 0.000 | 0.000 | 17.308 | 2.885 | 14.423 | 42.308 | 0.962 | -0.325 | -2.355 |
| **SSMS0175** | 40.000 | 2.857 | 10.476 | 34.286 | 0.952 | 11.429 | 5.714 | 10.476 | 23.810 | 0.000 | 1.306 | -0.841 |
| **SSMS0191** | 72.182 | 0.952 | 0.000 | 18.095 | 9.524 | 14.286 | 49.524 | 0.952 | 6.667 | 0.000 | 0.449 | -1.239 |
| **SSMS0193** | 89.636 | 0.000 | 0.000 | 0.000 | 0.000 | 0.952 | 0.000 | 54.286 | 39.048 | 3.810 | -1.868 | -3.064 |
| **SSMS0199** | 49.636 | 0.000 | 2.857 | 12.381 | 0.000 | 11.429 | 0.000 | 8.571 | 58.095 | 2.857 | 0.599 | -1.144 |
| **SSMS0213** | 50.909 | 10.476 | 6.667 | 26.667 | 21.905 | 2.857 | 14.286 | 5.714 | 8.571 | 0.000 | 1.442 | -0.535 |
| **SSMS0351** | 62.727 | 0.952 | 0.000 | 10.476 | 14.286 | 28.571 | 38.095 | 0.000 | 7.619 | 0.000 | 0.553 | -0.953 |
| **SSMS0408** | 36.727 | 0.000 | 0.000 | 2.857 | 0.000 | 37.143 | 29.524 | 0.000 | 7.619 | 5.714 | 0.220 | -1.317 |
| **SSMS0411** | 51.455 | 11.538 | 4.808 | 17.308 | 10.577 | 2.885 | 25.962 | 14.423 | 12.500 | 0.000 | 0.798 | -0.701 |
| **SSMS0447** | 55.636 | 36.190 | 5.714 | 0.000 | 0.000 | 3.810 | 46.667 | 0.000 | 6.667 | 0.000 | 1.439 | -0.068 |
| **SSMS1000** | 34.818 | 0.000 | 0.000 | 0.000 | 13.333 | 28.571 | 15.238 | 2.857 | 10.476 | 3.810 | 0.319 | -1.425 |
| **SSMS4173** | 56.818 | 0.000 | 7.619 | 32.381 | 5.714 | 4.762 | 7.619 | 35.238 | 6.667 | 0.000 | 0.270 | -1.882 |
| **SSMS4330** | 64.727 | 0.000 | 7.619 | 30.476 | 19.048 | 16.190 | 1.905 | 5.714 | 17.143 | 0.000 | 1.386 | -0.346 |
| **RENP0008** | 78.364 | 0.000 | 0.000 | 2.000 | 10.000 | 11.000 | 2.000 | 24.000 | 45.000 | 0.000 | -0.436 | -0.230 |
| **RENP0012** | 25.545 | 0.000 | 7.619 | 11.429 | 11.429 | 36.190 | 18.095 | 0.000 | 15.238 | 0.000 | 0.952 | 0.586 |
| **RENP0016** | 13.818 | 28.571 | 7.619 | 2.857 | 45.714 | 10.476 | 0.952 | 0.000 | 3.810 | 0.000 | 2.207 | 1.206 |
| **RENP0028** | 72.909 | 0.000 | 16.190 | 17.143 | 0.000 | 11.429 | 32.381 | 6.667 | 16.190 | 0.000 | 0.708 | 0.318 |
| **RENP0047** | 74.909 | 0.000 | 0.952 | 12.381 | 4.762 | 1.905 | 21.905 | 32.381 | 25.714 | 0.000 | -0.554 | -0.290 |
| **RENP0052** | 66.000 | 0.000 | 0.000 | 0.952 | 31.429 | 15.238 | 23.810 | 21.905 | 6.667 | 0.000 | 0.039 | 0.023 |

| | Mean embeddedness (%) | % of bedrock (>4000 mm) | % of boulders (250 to 4000 mm) | % of cobble (64 to 250mm) | % of coarse gravel (16 to 64 mm) | % of fine gravel (2 to 16mm) | % of sand (0.6 to2 mm) | % of fines (<0.6 mm) | Total Organic matter (%) | % of Wood | Log10 estimated geometric mean substrate diameter (mm) | Log10 - Relative Bed Stability (dimensionless: m/m)) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **XEMBED** | **PCT_BDRK** | **PCT_BL** | **PCT_CB** | **PCT_GC** | **PCT_GF** | **PCT_SA** | **PCT_FN** | **PCT_ORG** | **PCT_WD** | **LSUB_DMM** | **LRBS** |
| **RENP0054** | 74.182 | 0.000 | 0.000 | 0.000 | 0.000 | 0.952 | 25.714 | 39.048 | 34.286 | 0.000 | -1.422 | -0.590 |
| **RENP0055** | 54.727 | 0.000 | 0.000 | 0.000 | 17.925 | 11.321 | 4.717 | 8.491 | 19.811 | 0.000 | 0.192 | 0.102 |
| **RENP0075** | 39.636 | 14.286 | 0.000 | 9.524 | 24.762 | 18.095 | 15.238 | 0.952 | 17.143 | 0.000 | 1.394 | 0.922 |
| **RENP0092** | 97.273 | 1.000 | 3.000 | 0.000 | 0.000 | 0.000 | 71.000 | 1.000 | 24.000 | 0.000 | -0.302 | -0.241 |
| **RENP0095** | 79.818 | 0.000 | 0.000 | 0.000 | 0.000 | 0.943 | 2.830 | 62.264 | 21.698 | 0.000 | -1.684 | -0.794 |
| **RENP0096** | 59.091 | 0.000 | 2.857 | 2.857 | 15.238 | 24.762 | 24.762 | 10.476 | 11.429 | 0.000 | 0.246 | 0.146 |
| **RENP0097** | 55.818 | 14.286 | 0.000 | 22.857 | 3.810 | 4.762 | 26.667 | 9.524 | 18.095 | 0.000 | 0.960 | 0.483 |
| **RENP100** | 51.636 | 0.000 | 0.000 | 15.238 | 18.095 | 23.810 | 16.190 | 11.429 | 9.524 | 0.000 | 0.504 | 0.323 |
| **RENP0108** | 81.636 | 0.000 | 0.000 | 8.571 | 11.429 | 21.905 | 15.238 | 19.048 | 21.905 | 0.000 | 0.058 | 0.026 |
| **RENP0110** | 37.091 | 0.000 | 0.952 | 41.905 | 19.048 | 4.762 | 20.000 | 0.000 | 13.333 | 0.952 | 1.312 | 0.628 |
| **RENP0112** | 76.545 | 0.000 | 0.000 | 0.000 | 0.000 | 5.714 | 23.810 | 40.000 | 30.476 | 1.905 | -1.309 | -0.827 |
| **RENP0128** | 100.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.962 | 53.846 | 45.192 | 0.962 | -2.079 | -1.444 |
| **RENP0132** | 40.564 | 0.000 | 6.667 | 6.667 | 30.476 | 21.905 | 1.905 | 1.905 | 29.524 | 0.000 | 1.270 | 0.647 |
| **RENP0139** | 58.727 | 0.000 | 0.000 | 0.000 | 0.000 | 36.792 | 39.623 | 0.000 | 23.585 | 0.943 | 0.123 | 0.086 |
| **RENP0144** | 55.818 | 6.667 | 6.667 | 0.952 | 2.857 | 43.810 | 23.810 | 3.810 | 11.429 | 0.952 | 0.727 | 0.480 |
| **RENP0187** | 41.091 | 0.000 | 0.000 | 1.905 | 13.333 | 30.476 | 21.905 | 0.952 | 17.143 | 0.000 | 0.421 | 0.316 |
| **RENP0192** | 51.636 | 0.000 | 0.000 | 6.667 | 39.048 | 16.190 | 17.143 | 20.952 | 0.000 | 0.000 | 0.329 | 0.196 |
| **RENP0203** | 56.000 | 0.000 | 11.429 | 15.238 | 48.571 | 14.286 | 0.952 | 1.905 | 5.714 | 0.000 | 1.521 | 0.913 |
| **RENP0228** | 28.182 | 20.952 | 8.571 | 1.905 | 12.381 | 14.286 | 25.714 | 1.905 | 14.286 | 0.000 | 1.392 | 0.659 |
| **RENP0240** | 72.075 | 0.000 | 0.000 | 0.000 | 0.000 | 6.667 | 5.714 | 45.714 | 41.905 | 4.762 | -1.618 | -1.062 |
| **RENP0251** | 36.000 | 7.619 | 2.857 | 17.143 | 14.286 | 29.524 | 26.667 | 0.000 | 1.905 | 0.000 | 1.058 | 0.558 |
| **RENP0287** | 87.273 | 0.000 | 0.000 | 0.000 | 0.962 | 13.462 | 38.462 | 25.000 | 22.115 | 0.000 | -0.756 | -0.412 |
| **RENP0368** | 73.000 | 0.000 | 0.000 | 0.952 | 5.714 | 15.238 | 50.476 | 0.000 | 24.762 | 0.000 | -0.016 | -0.008 |
| **RENP0375** | 41.073 | 10.476 | 0.000 | 3.810 | 24.762 | 26.667 | 15.238 | 4.762 | 13.333 | 0.000 | 1.011 | 0.564 |
| **RENP0443** | 86.364 | 0.000 | 0.000 | 5.714 | 4.762 | 14.286 | 38.095 | 31.429 | 5.714 | 0.000 | -0.571 | -0.441 |
| **RENP0511** | 60.909 | 0.000 | 3.000 | 3.000 | 27.000 | 19.000 | 27.000 | 10.000 | 11.000 | 1.000 | 0.402 | 0.272 |
| **RENP1524** | 58.545 | 0.000 | 3.810 | 16.190 | 26.667 | 12.381 | 2.857 | 1.905 | 35.238 | 0.000 | 1.366 | 0.607 |
| **RENP2991** | 75.818 | 0.000 | 0.000 | 10.476 | 3.810 | 43.810 | 16.190 | 3.810 | 21.905 | 0.000 | 0.579 | 0.316 |
| **RENP5612** | 72.182 | 0.000 | 1.905 | 0.952 | 2.857 | 36.190 | 5.714 | 46.667 | 4.762 | 0.952 | -0.654 | -0.482 |
| **RENP7308** | 62.909 | 6.731 | 8.654 | 10.577 | 2.885 | 11.538 | 14.423 | 17.308 | 27.885 | 0.000 | 0.565 | 0.304 |
| **RENP9611** | 59.216 | 1.905 | 2.857 | 7.619 | 15.238 | 19.048 | 19.048 | 6.667 | 27.619 | 0.952 | 0.626 | 0.314 |

| | Mean embeddedness (%) | % of bedrock (>4000 mm) | % of boulders (250 to 4000 mm) | % of cobble (64 to 250mm) | % of coarse gravel (16 to 64 mm) | % of fine gravel (2 to 16mm) | % of sand (0.6 to2 mm) | % of fines (<0.6 mm) | Total Organic matter (%) | % of Wood | Log10 estimated geometric mean substrate diameter (mm) | Log10 - Relative Bed Stability (dimensionless: m/m)) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **XEMBED** | **PCT_BDRK** | **PCT_BL** | **PCT_CB** | **PCT_GC** | **PCT_GF** | **PCT_SA** | **PCT_FN** | **PCT_ORG** | **PCT_WD** | **LSUB_DMM** | **LRBS** |
| **RENP9757** | 33.333 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 1.905 | 4.762 | 0.000 | -0.042 | -0.025 |
| **RENP12892** | 72.182 | 0.000 | 0.952 | 13.333 | 6.667 | 16.190 | 22.857 | 29.524 | 3.810 | 0.000 | -0.207 | -0.108 |
| **RENP15048** | 78.364 | 0.000 | 0.000 | 1.905 | 4.762 | 16.190 | 1.905 | 64.762 | 6.667 | 0.000 | -1.222 | -0.687 |
| **RCA02** | 1.667 | 73.810 | 19.048 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 7.143 | 0.000 | -0.570 | 2.250 |
| **RCA08** | 77.222 | 9.091 | 9.091 | 0.000 | 0.000 | 3.030 | 33.333 | 45.455 | 0.000 | 0.000 | -3.082 | 2.606 |
| **RCA22** | 27.667 | 9.091 | 38.636 | 11.364 | 15.909 | 9.091 | 6.818 | 0.000 | 9.091 | 0.000 | 0.194 | 2.023 |
| **RCA23** | 57.667 | 4.444 | 0.000 | 8.889 | 22.222 | 22.222 | 13.333 | 15.556 | 13.333 | 0.000 | -2.017 | 2.555 |
| **RCA30** | 13.667 | 46.667 | 28.889 | 2.222 | 20.000 | 0.000 | 0.000 | 0.000 | 2.222 | 0.000 | 0.354 | 2.679 |
| **RCA31** | 75.000 | 0.000 | 0.000 | 18.182 | 12.121 | 18.182 | 51.515 | 0.000 | 0.000 | 0.000 | -1.602 | 2.067 |
| **RCA44** | 83.889 | 3.030 | 0.000 | 15.152 | 6.061 | 15.152 | 15.152 | 24.242 | 9.091 | 3.030 | -2.203 | 2.265 |
| **RCA48** | 44.000 | 6.667 | 0.000 | 33.333 | 20.000 | 6.667 | 11.111 | 0.000 | 20.000 | 4.444 | -0.333 | 1.896 |
| **RCA49** | 52.667 | 22.222 | 0.000 | 0.000 | 13.333 | 17.778 | 15.556 | 6.667 | 24.444 | 2.222 | -0.569 | 1.835 |
| **RCA50** | 42.000 | 42.222 | 0.000 | 8.889 | 17.778 | 11.111 | 15.556 | 0.000 | 4.444 | 0.000 | 0.726 | 1.420 |
| **RCA52** | 62.833 | 0.000 | 0.000 | 20.000 | 28.889 | 15.556 | 6.667 | 0.000 | 22.222 | 0.000 | -0.271 | 1.482 |
| **RCA53** | 30.500 | 26.667 | 0.000 | 40.000 | 22.222 | 4.444 | 6.667 | 0.000 | 0.000 | 0.000 | -0.390 | 2.568 |
| **RCA57** | 5.000 | 63.636 | 20.455 | 4.545 | 4.545 | 0.000 | 0.000 | 0.000 | 6.818 | 0.000 | 1.571 | 1.826 |
| **RCA58** | 5.000 | 64.444 | 31.111 | 4.444 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.905 | 2.540 |
| **RCA59** | 0.667 | 95.556 | 2.222 | 2.222 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.859 | 2.841 |
| **RCA60** | 0.000 | 100.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.269 | 3.484 |
| **RCA62** | 7.667 | 13.636 | 0.000 | 0.000 | 9.091 | 9.091 | 2.273 | 0.000 | 65.909 | 0.000 | -1.045 | 3.118 |
| **RCA64** | 26.167 | 53.333 | 6.667 | 2.222 | 26.667 | 6.667 | 2.222 | 0.000 | 2.222 | 0.000 | -0.711 | 3.462 |
| **RCA65** | 87.778 | 0.000 | 3.030 | 0.000 | 0.000 | 12.121 | 81.818 | 0.000 | 3.030 | 0.000 | -2.404 | 2.203 |
| **RCA66** | 80.556 | 0.000 | 24.242 | 9.091 | 12.121 | 15.152 | 30.303 | 0.000 | 9.091 | 0.000 | -1.088 | 2.271 |
| **RCA67** | 71.111 | 0.000 | 9.091 | 18.182 | 12.121 | 18.182 | 30.303 | 3.030 | 6.061 | 0.000 | -1.313 | 2.133 |
| **RCA68** | 42.222 | 42.424 | 0.000 | 3.030 | 18.182 | 9.091 | 15.152 | 0.000 | 12.121 | 0.000 | -0.149 | 2.343 |
| **RCA69** | 53.500 | 4.444 | 0.000 | 42.222 | 13.333 | 6.667 | 17.778 | 0.000 | 8.889 | 0.000 | -0.816 | 2.159 |
| **RCA70** | 22.778 | 46.875 | 0.000 | 3.125 | 0.000 | 0.000 | 18.750 | 0.000 | 15.625 | 3.125 | -0.234 | 2.294 |
| **RCA71** | 67.778 | 18.182 | 0.000 | 15.152 | 3.030 | 0.000 | 39.394 | 24.242 | 0.000 | 0.000 | -1.885 | 2.239 |
| **RCA72** | 54.250 | 9.091 | 0.000 | 13.636 | 34.091 | 20.455 | 11.364 | 6.818 | 4.545 | 0.000 | -0.344 | 1.495 |
| **RCA73** | 47.333 | 2.222 | 0.000 | 35.556 | 44.444 | 0.000 | 17.778 | 0.000 | 0.000 | 0.000 | -0.553 | 1.971 |
| **RCA74** | 59.333 | 18.605 | 2.326 | 16.279 | 11.628 | 23.256 | 13.953 | 9.302 | 2.326 | 0.000 | -0.843 | 2.072 |

| | Mean embeddedness (%) | % of bedrock (>4000 mm) | % of boulders (250 to 4000 mm) | % of cobble (64 to 250mm) | % of coarse gravel (16 to 64 mm) | % of fine gravel (2 to 16mm) | % of sand (0.6 to2 mm) | % of fines (<0.6 mm) | Total Organic matter (%) | % of Wood | Log10 estimated geometric mean substrate diameter (mm) | Log10 - Relative Bed Stability (dimensionless: m/m)) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **XEMBED** | **PCT_BDRK** | **PCT_BL** | **PCT_CB** | **PCT_GC** | **PCT_GF** | **PCT_SA** | **PCT_FN** | **PCT_ORG** | **PCT_WD** | **LSUB_DMM** | **LRBS** |
| **RCA90** | 64.000 | 17.778 | 0.000 | 0.000 | 6.667 | 20.000 | 20.000 | 22.222 | 13.333 | 0.000 | -0.680 | 1.091 |

**Table 2.5.** Flow variables.

| | Flow - instantaneous discharge (m3/s) | Velocity mean (m/s) | Glides (%) | Percentage of rapids and riffles (%) | Percentage of pools | Sequence fasts, glides and pools (1= maximum Heterogenity, 0= maximum homogenity ) |
|---|---|---|---|---|---|---|
| | **FLOW_2** | **XVEL** | **PCT_GL** | **PCT_FAST** | **PCT_POOL** | **SEQ_FLO_1** |
| **TMMS0003** | 0.0291 | 0.0932 | 76.0000 | 24.0000 | 0.0000 | 0.0940 |
| **TMMS0007** | 0.0675 | 0.0484 | 50.0000 | 20.0000 | 30.0000 | 0.0268 |
| **TMMS0009** | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 100.0000 | 0.0000 |
| **TMMS0027** | 0.0000 | 0.0000 | 17.3333 | 0.0000 | 82.6667 | 0.0940 |
| **TMMS0028** | 0.0597 | 0.1104 | 73.0000 | 17.0000 | 10.0000 | 0.1111 |
| **TMMS0033** | 0.0002 | 0.0044 | 48.6667 | 6.0000 | 45.3333 | 0.0671 |
| **TMMS0040** | 0.0001 | 0.0036 | 16.1074 | 4.6980 | 79.1946 | 0.2365 |
| **TMMS0043** | 0.0020 | 0.0074 | 80.0000 | 16.6667 | 3.3333 | 0.0604 |
| **TMMS0058** | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 100.0000 | 0.0000 |
| **TMMS0072** | 0.0121 | 0.0288 | 18.0000 | 21.0000 | 61.0000 | 0.1313 |
| **TMMS0082** | 0.0359 | 0.0497 | 0.0000 | 0.0000 | 100.0000 | 0.0000 |
| **TMMS0088** | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 100.0000 | 0.0000 |
| **TMMS0090** | 0.0013 | 0.0049 | 10.6667 | 6.6667 | 82.6667 | 0.0671 |
| **TMMS0091** | 0.0949 | 0.0703 | 59.3333 | 40.6667 | 0.0000 | 0.0537 |
| **TMMS0106** | 0.0002 | 0.0007 | 4.0000 | 0.0000 | 96.0000 | 0.0134 |
| **TMMS0119** | 0.0171 | 0.0465 | 71.4286 | 7.1429 | 21.4286 | 0.1357 |
| **TMMS0126** | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 100.0000 | 0.0000 |
| **TMMS0133** | 0.0568 | 0.1420 | 40.0000 | 2.6667 | 57.3333 | 0.0822 |
| **TMMS0134** | 0.0003 | 0.0029 | 1.3333 | 7.3333 | 91.3333 | 0.1074 |
| **TMMS0137** | 0.0003 | 0.0003 | 0.0000 | 0.0000 | 100.0000 | 0.0000 |
| **TMMS0159** | 0.3901 | 0.0813 | 90.6667 | 9.3333 | 0.0000 | 0.0403 |
| **TMMS0171** | 0.1584 | 0.0495 | 38.6667 | 45.3333 | 16.0000 | 0.1088 |
| **TMMS0178** | 0.0652 | 0.1195 | 86.0000 | 14.0000 | 0.0000 | 0.0336 |
| **TMMS0183** | 0.0199 | 0.0354 | 15.9722 | 13.1944 | 70.8333 | 0.1141 |
| **TMMS0187** | 0.1932 | 0.2609 | 26.6667 | 32.0000 | 41.3333 | 0.1007 |
| **TMMS0193** | 0.1372 | 0.1579 | 88.0000 | 6.6667 | 5.3333 | 0.0405 |
| **TMMS0209** | 0.0197 | 0.0172 | 2.7972 | 0.0000 | 97.2028 | 0.0250 |
| **TMMS0214** | 0.0110 | 0.0183 | 68.6667 | 0.0000 | 31.3333 | 0.0268 |
| **TMMS0220** | 0.0002 | 0.0038 | 38.0000 | 34.6667 | 27.3333 | 0.1208 |
| **TMMS0279** | 0.1146 | 0.0537 | 78.0000 | 22.0000 | 0.0000 | 0.0872 |
| **TMMS0283** | 0.0648 | 0.0956 | 65.3333 | 22.6667 | 12.0000 | 0.2081 |

| | Flow - instantaneous discharge (m3/s) | Velocity mean (m/s) | Glides (%) | Percentage of rapids and riffles (%) | Percentage of pools | Sequence fasts, glides and pools (1= maximum Heterogenity, 0= maximum homogenity ) |
|---|---|---|---|---|---|---|
| | **FLOW_2** | **XVEL** | **PCT_GL** | **PCT_FAST** | **PCT_POOL** | **SEQ_FLO_1** |
| **TMMS0290** | 0.0002 | 0.0011 | 40.6667 | 2.0000 | 57.3333 | 0.0336 |
| **TMMS0296** | 0.1425 | 0.1043 | 49.0000 | 21.0000 | 30.0000 | 0.1818 |
| **TMMS0381** | 0.0076 | 0.0773 | 62.0000 | 4.6667 | 33.3333 | 0.1342 |
| **TMMS0391** | 0.0170 | 0.0874 | 38.6667 | 1.3333 | 60.0000 | 0.0946 |
| **TMMS0437** | 0.0570 | 0.2983 | 50.0000 | 17.3333 | 32.6667 | 0.1141 |
| **TMMS1865** | 0.0018 | 0.0060 | 2.6667 | 0.0000 | 97.3333 | 0.0137 |
| **TMMS3195** | 0.0003 | 0.0042 | 14.6667 | 6.0000 | 79.3333 | 0.0805 |
| **TMMS3962** | 0.0033 | 0.0047 | 10.6667 | 0.0000 | 89.3333 | 0.0403 |
| **VGMS00002** | 0.0151 | 0.1415 | 67.3333 | 4.6667 | 28.0000 | 0.1074 |
| **VGMS00004** | 0.1499 | 0.1363 | 70.0000 | 26.0000 | 4.0000 | 0.0671 |
| **VGMS00016** | 0.9078 | 0.3875 | 84.5455 | 15.4545 | 0.0000 | 0.0642 |
| **VGMS00018** | 0.0407 | 0.5286 | 62.6667 | 37.3333 | 0.0000 | 0.1007 |
| **VGMS00022** | 0.0530 | 0.1867 | 32.6667 | 67.3333 | 0.0000 | 0.1141 |
| **VGMS00034** | 0.0840 | 0.0909 | 23.3333 | 9.3333 | 67.3333 | 0.1208 |
| **VGMS00037** | 0.1299 | 0.3335 | 6.6667 | 93.3333 | 0.0000 | 0.0096 |
| **VGMS00044** | 0.0520 | 0.0796 | 93.1034 | 6.8966 | 0.0000 | 0.0537 |
| **VGMS00048** | 0.3971 | 0.4971 | 46.6667 | 53.3333 | 0.0000 | 0.0672 |
| **VGMS00080** | 0.5496 | 0.4129 | 16.0000 | 84.0000 | 0.0000 | 0.0268 |
| **VGMS00109** | 0.3092 | 0.2691 | 96.6667 | 3.3333 | 0.0000 | 0.0134 |
| **VGMS00112** | 0.7043 | 0.3340 | 46.6667 | 53.3333 | 0.0000 | 0.0470 |
| **VGMS00121** | 0.0354 | 0.0817 | 72.6667 | 27.3333 | 0.0000 | 0.0403 |
| **VGMS00124** | 0.4258 | 0.3047 | 47.0588 | 46.2185 | 6.7227 | 0.0470 |
| **VGMS00126** | 0.0873 | 0.3355 | 48.0000 | 52.0000 | 0.0000 | 0.0604 |
| **VGMS00128** | 0.0602 | 0.2688 | 96.0000 | 2.0000 | 2.0000 | 0.0336 |
| **VGMS00162** | 0.2480 | 0.3301 | 94.6667 | 4.0000 | 1.3333 | 0.0268 |
| **VGMS00177** | 0.1036 | 0.4403 | 81.6176 | 16.9118 | 1.4706 | 0.0940 |
| **VGMS00191** | 0.3891 | 0.3180 | 69.3333 | 30.6667 | 0.0000 | 0.0805 |
| **VGMS00206** | 0.0184 | 0.1591 | 70.3704 | 0.0000 | 29.6296 | 0.1208 |
| **VGMS00210** | 0.3277 | 0.5722 | 100.0000 | 0.0000 | 0.0000 | 0.0000 |
| **VGMS00247** | 0.0568 | 0.1491 | 74.0000 | 26.0000 | 0.0000 | 0.0940 |
| **VGMS00252** | 0.5816 | 0.2761 | 78.0000 | 22.0000 | 0.0000 | 0.0671 |
| **VGMS00255** | 0.5092 | 0.4935 | 86.0000 | 14.0000 | 0.0000 | 0.0134 |

| | Flow - instantaneous discharge (m3/s) | Velocity mean (m/s) | Glides (%) | Percentage of rapids and riffles (%) | Percentage of pools | Sequence fasts, glides and pools (1= maximum Heterogenity, 0= maximum homogenity ) |
|---|---|---|---|---|---|---|
| | **FLOW_2** | **XVEL** | **PCT_GL** | **PCT_FAST** | **PCT_POOL** | **SEQ_FLO_1** |
| **VGMS00277** | 0.5601 | 0.1877 | 82.0000 | 18.0000 | 0.0000 | 0.0671 |
| **VGMS00306** | 0.1891 | 0.1751 | 26.0000 | 74.0000 | 0.0000 | 0.0738 |
| **VGMS00320** | 0.2405 | 0.1121 | 0.0000 | 88.0000 | 12.0000 | 0.0268 |
| **VGMS00380** | 0.2816 | 0.2283 | 74.6667 | 25.3333 | 0.0000 | 0.0201 |
| **VGMS00387** | 0.2427 | 0.2549 | 80.0000 | 19.3333 | 0.6667 | 0.0403 |
| **VGMS00418** | 0.0472 | 0.1341 | 55.3333 | 26.0000 | 18.6667 | 0.1208 |
| **VGMS00433** | 0.3676 | 0.1324 | 96.0000 | 4.0000 | 0.0000 | 0.0201 |
| **VGMS00444** | 0.6650 | 0.3421 | 40.0000 | 60.0000 | 0.0000 | 0.1007 |
| **VGMS00447** | 0.4492 | 0.3289 | 76.0000 | 24.0000 | 0.0000 | 0.0537 |
| **VGMS00450** | 0.7561 | 0.6293 | 57.0370 | 35.5556 | 7.4074 | 0.0738 |
| **VGMS00511** | 0.2233 | 0.3191 | 11.3333 | 88.6667 | 0.0000 | 0.0403 |
| **VGMS00515** | 0.1105 | 0.1869 | 36.9231 | 52.3077 | 10.7692 | 0.0940 |
| **VGMS00558** | 0.3000 | 0.5949 | 50.6667 | 49.3333 | 0.0000 | 0.1409 |
| **VGMS00575** | 0.3267 | 0.3721 | 20.6667 | 79.3333 | 0.0000 | 0.0671 |
| **SSMS0001** | 0.2007 | 0.4589 | 36.0000 | 64.0000 | 0.0000 | 0.0671 |
| **SSMS0002** | 0.2408 | 0.1599 | 58.6667 | 41.3333 | 0.0000 | 0.0336 |
| **SSMS0008** | 0.0302 | 0.1748 | 46.6667 | 33.3333 | 20.0000 | 0.1611 |
| **SSMS0010** | 0.5715 | 0.2525 | 56.6667 | 43.3333 | 0.0000 | 0.0671 |
| **SSMS0014** | 0.1076 | 0.1817 | 36.6667 | 63.3333 | 0.0000 | 0.0940 |
| **SSMS0028** | 0.0813 | 0.1741 | 70.6667 | 29.3333 | 0.0000 | 0.0671 |
| **SSMS0029** | 0.5194 | 0.2731 | 100.0000 | 0.0000 | 0.0000 | 0.0000 |
| **SSMS0031** | 0.0029 | 0.0150 | 98.6667 | 1.3333 | 0.0000 | 0.0134 |
| **SSMS0033** | 6.1153 | 22.3056 | 56.6667 | 43.3333 | 0.0000 | 0.0604 |
| **SSMS0035** | 0.7591 | 0.2823 | 42.6667 | 57.3333 | 0.0000 | 0.0470 |
| **SSMS0037** | 0.1039 | 0.1276 | 90.0000 | 10.0000 | 0.0000 | 0.0268 |
| **SSMS0038** | 0.0907 | 0.1341 | 95.3333 | 0.0000 | 4.6667 | 0.0268 |
| **SSMS0044** | 0.1495 | 0.1999 | 85.3333 | 14.6667 | 0.0000 | 0.0134 |
| **SSMS0051** | 0.0594 | 0.1573 | 77.3333 | 20.6667 | 2.0000 | 0.1074 |
| **SSMS0053** | 0.1649 | 0.7061 | 89.3333 | 8.6667 | 2.0000 | 0.0403 |
| **SSMS0057** | 0.2127 | 0.4248 | 44.0000 | 6.0000 | 50.0000 | 0.1275 |
| **SSMS0059** | 0.0313 | 0.2177 | 86.6667 | 13.3333 | 0.0000 | 0.1007 |
| **SSMS0073** | 0.3291 | 0.2159 | 80.6667 | 19.3333 | 0.0000 | 0.0537 |

| | Flow - instantaneous discharge (m3/s) | Velocity mean (m/s) | Glides (%) | Percentage of rapids and riffles (%) | Percentage of pools | Sequence fasts, glides and pools (1= maximum Heterogenity, 0= maximum homogenity ) |
|---|---|---|---|---|---|---|
| | **FLOW_2** | **XVEL** | **PCT_GL** | **PCT_FAST** | **PCT_POOL** | **SEQ_FLO_1** |
| **SSMS0078** | 0.2808 | 0.3466 | 85.3333 | 14.6667 | 0.0000 | 0.0537 |
| **SSMS0094** | 0.2233 | 0.2824 | 22.6667 | 77.3333 | 0.0000 | 0.0268 |
| **SSMS0105** | 0.4215 | 0.4995 | 77.3333 | 22.6667 | 0.0000 | 0.1275 |
| **SSMS0126** | 0.3048 | 0.3761 | 96.6667 | 3.3333 | 0.0000 | 0.0135 |
| **SSMS0129** | 0.2592 | 0.3381 | 100.0000 | 0.0000 | 0.0000 | 0.0000 |
| **SSMS0133** | 0.2934 | 0.1289 | 86.6667 | 11.3333 | 2.0000 | 0.0738 |
| **SSMS0144** | 0.0267 | 0.2040 | 54.0000 | 14.6667 | 31.3333 | 0.2081 |
| **SSMS0149** | 0.4450 | 0.3222 | 80.0000 | 20.0000 | 0.0000 | 0.0268 |
| **SSMS0150** | 0.4061 | 0.3880 | 65.3333 | 28.0000 | 6.6667 | 0.1342 |
| **SSMS0157** | 0.1957 | 1.2776 | 24.6667 | 18.0000 | 57.3333 | 0.0946 |
| **SSMS0175** | 0.1113 | 0.2013 | 59.3333 | 40.6667 | 0.0000 | 0.0671 |
| **SSMS0191** | 0.1790 | 0.1898 | 58.6667 | 41.3333 | 0.0000 | 0.0671 |
| **SSMS0193** | 0.2062 | 0.2543 | 98.0000 | 2.0000 | 0.0000 | 0.0134 |
| **SSMS0199** | 0.1552 | 0.1590 | 78.5235 | 21.4765 | 0.0000 | 0.0537 |
| **SSMS0213** | 5.7423 | 3.2617 | 67.3333 | 32.6667 | 0.0000 | 0.0872 |
| **SSMS0351** | 0.7221 | 0.4760 | 54.0000 | 46.0000 | 0.0000 | 0.0336 |
| **SSMS0408** | 0.1012 | 0.2662 | 82.6667 | 17.3333 | 0.0000 | 0.0470 |
| **SSMS0411** | 0.3034 | 0.1894 | 64.6667 | 35.3333 | 0.0000 | 0.0470 |
| **SSMS0447** | 0.7193 | 0.4445 | 47.6510 | 52.3490 | 0.0000 | 0.0470 |
| **SSMS1000** | 0.1738 | 0.5327 | 32.6667 | 67.3333 | 0.0000 | 0.0671 |
| **SSMS4173** | 0.5314 | 0.2638 | 62.6667 | 37.3333 | 0.0000 | 0.0336 |
| **SSMS4330** | 0.1910 | 0.2365 | 58.0000 | 42.0000 | 0.0000 | 0.0671 |
| **RENP0008** | 0.0999 | 0.1580 | 47.3684 | 27.8195 | 24.8120 | 0.0746 |
| **RENP0012** | 0.0734 | 0.1739 | 50.0000 | 40.0000 | 10.0000 | 0.1892 |
| **RENP0016** | 0.2859 | 0.0568 | 76.6667 | 13.3333 | 10.0000 | 0.0671 |
| **RENP0028** | 0.1208 | 0.2016 | 64.6667 | 31.3333 | 4.0000 | 0.1611 |
| **RENP0047** | 0.0565 | 0.7683 | 87.3333 | 2.6667 | 10.0000 | 0.0336 |
| **RENP0052** | 0.0659 | 0.2340 | 50.0000 | 50.0000 | 0.0000 | 0.0604 |
| **RENP0054** | 0.0019 | 1.3738 | 88.6667 | 3.3333 | 8.0000 | 0.1208 |
| **RENP0055** | 0.0780 | 0.2456 | 96.0000 | 1.3333 | 2.6667 | 0.0268 |
| **RENP0075** | 0.1676 | 0.1790 | 62.0000 | 16.0000 | 22.0000 | 0.0604 |
| **RENP0092** | 0.0067 | 1.0079 | 96.0000 | 4.0000 | 0.0000 | 0.0268 |

| | Flow - instantaneous discharge (m3/s) | Velocity mean (m/s) | Glides (%) | Percentage of rapids and riffles (%) | Percentage of pools | Sequence fasts, glides and pools (1= maximum Heterogenity, 0= maximum homogenity ) |
|---|---|---|---|---|---|---|
| | **FLOW_2** | **XVEL** | **PCT_GL** | **PCT_FAST** | **PCT_POOL** | **SEQ_FLO_1** |
| **RENP0095** | 0.0219 | 0.2623 | 83.3333 | 16.6667 | 0.0000 | 0.0671 |
| **RENP0096** | 0.0877 | 0.2438 | 80.0000 | 20.0000 | 0.0000 | 0.0805 |
| **RENP0097** | 0.1081 | 0.2818 | 37.3333 | 45.3333 | 17.3333 | 0.1141 |
| **RENP100** | 0.1099 | 0.2790 | 74.0000 | 26.0000 | 0.0000 | 0.0604 |
| **RENP0108** | 0.0402 | 0.4055 | 43.3333 | 56.6667 | 0.0000 | 0.0872 |
| **RENP0110** | 0.1924 | 0.1784 | 38.0000 | 62.0000 | 0.0000 | 0.1141 |
| **RENP0112** | 0.2303 | 1.2099 | 90.6667 | 4.0000 | 5.3333 | 0.0671 |
| **RENP0128** | 0.0717 | 0.2317 | 92.0000 | 2.0000 | 6.0000 | 0.0671 |
| **RENP0132** | 0.0258 | 0.4516 | 78.0000 | 17.3333 | 4.6667 | 0.1007 |
| **RENP0139** | 0.0813 | 0.2149 | 100.0000 | 0.0000 | 0.0000 | 0.0000 |
| **RENP0144** | 0.0253 | 0.1572 | 18.0000 | 9.3333 | 72.6667 | 0.1074 |
| **RENP0187** | 0.0623 | 0.3585 | 90.0000 | 10.0000 | 0.0000 | 0.0134 |
| **RENP0192** | 0.3894 | 0.2228 | 31.3333 | 68.6667 | 0.0000 | 0.0268 |
| **RENP0203** | 0.0943 | 0.1899 | 88.0000 | 3.3333 | 8.6667 | 0.0537 |
| **RENP0228** | 0.1228 | 0.3144 | 65.3333 | 34.6667 | 0.0000 | 0.0872 |
| **RENP0240** | 0.0142 | 0.5865 | 71.3333 | 2.0000 | 26.6667 | 0.0537 |
| **RENP0251** | 0.0284 | 0.4233 | 36.6667 | 54.6667 | 8.6667 | 0.1409 |
| **RENP0287** | 0.0036 | 0.8560 | 72.0000 | 0.0000 | 28.0000 | 0.0537 |
| **RENP0368** | 0.0759 | 0.2086 | 80.6667 | 19.3333 | 0.0000 | 0.0537 |
| **RENP0375** | 0.1719 | 0.0726 | 72.0000 | 15.3333 | 12.6667 | 0.0872 |
| **RENP0443** | 0.1006 | 0.2209 | 55.3333 | 44.6667 | 0.0000 | 0.0537 |
| **RENP0511** | 0.2879 | 0.1332 | 42.0000 | 58.0000 | 0.0000 | 0.0671 |
| **RENP1524** | 0.0460 | 0.3196 | 80.0000 | 12.0000 | 8.0000 | 0.0671 |
| **RENP2991** | 0.0624 | 0.2043 | 90.0000 | 10.0000 | 0.0000 | 0.0671 |
| **RENP5612** | 0.3644 | 0.1625 | 32.0000 | 68.0000 | 0.0000 | 0.0067 |
| **RENP7308** | 0.0297 | 0.6503 | 82.6667 | 17.3333 | 0.0000 | 0.1879 |
| **RENP9611** | 0.0257 | 0.5661 | 92.6667 | 7.3333 | 0.0000 | 0.0805 |
| **RENP9757** | 0.1994 | 0.3649 | 39.3333 | 11.3333 | 49.3333 | 0.0134 |
| **RENP12892** | 0.1274 | 0.8781 | 20.6667 | 79.3333 | 0.0000 | 0.1007 |
| **RENP15048** | 0.5958 | 0.1926 | 10.0000 | 90.0000 | 0.0000 | 0.0537 |
| **RCA02** | 0.0514 | 0.0573 | 35.0000 | 65.0000 | 0.0000 | 0.2917 |
| **RCA08** | 0.0013 | 0.0060 | 100.0000 | 0.0000 | 0.0000 | 0.2414 |

| | Flow - instantaneous discharge (m3/s) | Velocity mean (m/s) | Glides (%) | Percentage of rapids and riffles (%) | Percentage of pools | Sequence fasts, glides and pools (1= maximum Heterogenity, 0= maximum homogenity ) |
|---|---|---|---|---|---|---|
| | **FLOW_2** | **XVEL** | **PCT_GL** | **PCT_FAST** | **PCT_POOL** | **SEQ_FLO_1** |
| **RCA22** | 0.0431 | 0.0201 | 60.8696 | 30.4348 | 4.3478 | 0.3750 |
| **RCA23** | 0.0204 | 0.0499 | 100.0000 | 0.0000 | 0.0000 | 0.2500 |
| **RCA30** | 0.2476 | 0.0753 | 66.6667 | 33.3333 | 0.0000 | 0.0833 |
| **RCA31** | 0.0713 | 0.1852 | 52.6316 | 47.3684 | 0.0000 | 0.3793 |
| **RCA44** | 0.0151 | 0.3262 | 58.3333 | 41.6667 | 0.0000 | 0.5862 |
| **RCA48** | 0.2086 | 0.5424 | 0.0000 | 100.0000 | 0.0000 | 0.0345 |
| **RCA49** | 0.1257 | 0.2602 | 86.9565 | 13.0435 | 0.0000 | 0.2069 |
| **RCA50** | 1.2634 | 0.5041 | 83.3333 | 16.6667 | 0.0000 | 0.1034 |
| **RCA52** | 0.4571 | 0.4594 | 88.4615 | 11.5385 | 0.0000 | 0.0690 |
| **RCA53** | 0.2878 | 0.6923 | 23.3333 | 76.6667 | 0.0000 | 0.1379 |
| **RCA57** | 0.0633 | 0.0336 | 100.0000 | 0.0000 | 0.0000 | 0.0000 |
| **RCA58** | 0.0097 | 0.0749 | 40.0000 | 60.0000 | 0.0000 | 0.2500 |
| **RCA59** | 0.0386 | 0.0465 | 63.6364 | 36.3636 | 0.0000 | 0.2083 |
| **RCA60** | 0.0000 | 0.0000 | 8.0000 | 92.0000 | 0.0000 | 0.1250 |
| **RCA62** | 0.0007 | 0.0587 | 100.0000 | 0.0000 | 0.0000 | 0.4167 |
| **RCA64** | 0.0035 | 0.0544 | 56.2500 | 43.7500 | 0.0000 | 0.4583 |
| **RCA65** | 0.0077 | 0.1763 | 72.4138 | 27.5862 | 0.0000 | 0.3448 |
| **RCA66** | 0.0086 | 0.0517 | 65.2174 | 34.7826 | 0.0000 | 0.3448 |
| **RCA67** | 0.0086 | 0.0513 | 61.9048 | 38.0952 | 0.0000 | 0.3448 |
| **RCA68** | 0.0705 | 0.4447 | 31.8182 | 68.1818 | 0.0000 | 0.1379 |
| **RCA69** | 0.2382 | 0.5061 | 34.6154 | 65.3846 | 0.0000 | 0.1034 |
| **RCA70** | 0.1505 | 0.4132 | 50.0000 | 50.0000 | 0.0000 | 0.2069 |
| **RCA71** | 0.0212 | 0.1122 | 68.1818 | 31.8182 | 0.0000 | 0.4828 |
| **RCA72** | 0.1355 | 0.1598 | 86.6667 | 13.3333 | 0.0000 | 0.0690 |
| **RCA73** | 0.4721 | 0.6092 | 30.0000 | 70.0000 | 0.0000 | 0.1034 |
| **RCA74** | 0.0000 | 0.0000 | 33.3333 | 66.6667 | 0.0000 | 0.0690 |
| **RCA90** | 0.4612 | 0.4363 | 100.0000 | 0.0000 | 0.0000 | 0.0345 |

**Table 2.6.** Vegetation canopy cover variables.

| | Mean mid-channel canopy density (%) | Mean canopy cover > 0.3m DBH | Mean canopy cover <= 0.3m DBH | Mean woody mid-layer cover | Mean herbaceous mid-layer cover | Mean woody ground-layer cover | Mean herbaceous ground-layer cover | Mean exposed soil | Mean riparian veg canopy cover | Mean riparian veg mid-layer cover | Mean riparian veg ground cover |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **XCDENMID** | **XCL** | **XCS** | **XMW** | **XMH** | **XGW** | **XGH** | **XGB** | **XC** | **XM** | **XG** |
| **TMMS0003** | 93.984 | 2.273 | 8.182 | 13.636 | 14.659 | 12.273 | 18.864 | 15.000 | 10.455 | 28.295 | 31.136 |
| **TMMS0007** | 75.802 | 39.545 | 45.227 | 48.864 | 53.523 | 41.705 | 50.455 | 8.636 | 84.773 | 102.386 | 92.159 |
| **TMMS0009** | 65.909 | 3.636 | 6.818 | 17.955 | 12.841 | 8.636 | 25.455 | 42.614 | 10.455 | 30.795 | 34.091 |
| **TMMS0027** | 88.235 | 4.318 | 12.955 | 24.886 | 7.727 | 9.545 | 12.273 | 27.841 | 17.273 | 32.614 | 21.818 |
| **TMMS0028** | 84.893 | 6.591 | 13.182 | 19.091 | 16.477 | 19.886 | 22.045 | 22.159 | 19.773 | 35.568 | 41.932 |
| **TMMS0033** | 94.519 | 2.045 | 18.636 | 21.136 | 20.227 | 21.250 | 17.955 | 29.886 | 20.682 | 41.364 | 39.205 |
| **TMMS0040** | 84.492 | 2.045 | 3.182 | 15.568 | 41.705 | 12.273 | 41.591 | 5.000 | 5.227 | 57.273 | 53.864 |
| **TMMS0043** | 79.813 | 1.591 | 10.341 | 12.841 | 10.227 | 11.250 | 15.909 | 29.091 | 11.932 | 23.068 | 27.159 |
| **TMMS0058** | 75.668 | 2.500 | 7.955 | 26.364 | 2.955 | 8.636 | 17.045 | 50.000 | 10.455 | 29.318 | 25.682 |
| **TMMS0072** | 71.791 | 6.591 | 18.295 | 17.045 | 18.295 | 9.318 | 22.955 | 36.023 | 24.886 | 35.341 | 32.273 |
| **TMMS0082** | 83.021 | 1.591 | 4.091 | 12.727 | 19.091 | 3.864 | 13.295 | 66.818 | 5.682 | 31.818 | 17.159 |
| **TMMS0088** | 68.583 | 1.364 | 5.000 | 19.091 | 15.568 | 18.295 | 22.500 | 26.023 | 6.364 | 34.659 | 40.795 |
| **TMMS0090** | 97.727 | 4.545 | 18.636 | 21.364 | 6.818 | 9.545 | 14.318 | 22.159 | 23.182 | 28.182 | 23.864 |
| **TMMS0091** | 53.476 | 1.364 | 8.864 | 13.977 | 9.773 | 12.273 | 10.000 | 35.227 | 10.227 | 23.750 | 22.273 |
| **TMMS0106** | 99.599 | 4.318 | 9.545 | 40.000 | 11.023 | 20.114 | 11.932 | 53.068 | 13.864 | 51.023 | 32.045 |
| **TMMS0119** | 95.722 | 3.182 | 5.227 | 22.386 | 32.386 | 5.000 | 29.545 | 15.909 | 8.409 | 54.773 | 34.545 |
| **TMMS0126** | 94.251 | 5.455 | 15.795 | 30.909 | 11.023 | 19.205 | 15.227 | 8.182 | 21.250 | 41.932 | 34.432 |
| **TMMS0133** | 83.021 | 4.091 | 4.773 | 13.750 | 37.045 | 9.545 | 31.705 | 17.159 | 8.864 | 50.795 | 41.250 |
| **TMMS0134** | 94.385 | 12.727 | 28.750 | 25.227 | 5.909 | 5.909 | 13.409 | 37.159 | 41.477 | 31.136 | 19.318 |
| **TMMS0137** | 87.701 | 16.364 | 10.909 | 7.045 | 4.091 | 10.000 | 9.659 | 30.227 | 27.273 | 11.136 | 19.659 |
| **TMMS0159** | 43.182 | 7.727 | 20.909 | 27.273 | 22.614 | 17.841 | 33.523 | 27.045 | 28.636 | 49.886 | 51.364 |
| **TMMS0171** | 16.578 | 0.227 | 0.682 | 19.886 | 12.273 | 5.000 | 45.568 | 36.023 | 0.909 | 32.159 | 50.568 |
| **TMMS0178** | 82.888 | 1.591 | 8.864 | 36.136 | 12.386 | 20.682 | 20.114 | 30.227 | 10.455 | 48.523 | 40.795 |
| **TMMS0183** | 96.524 | 4.545 | 26.932 | 40.341 | 14.318 | 27.841 | 5.000 | 17.727 | 31.477 | 54.659 | 32.841 |
| **TMMS0187** | 92.914 | 2.727 | 6.136 | 33.750 | 11.932 | 10.455 | 14.318 | 31.705 | 8.864 | 45.682 | 24.773 |
| **TMMS0193** | 76.070 | 15.455 | 19.091 | 17.386 | 15.568 | 11.932 | 63.523 | 5.682 | 34.545 | 32.955 | 75.455 |
| **TMMS0209** | 89.037 | 36.250 | 27.727 | 42.727 | 47.159 | 28.977 | 20.341 | 1.591 | 63.977 | 89.886 | 49.318 |
| **TMMS0214** | 75.000 | 0.227 | 2.500 | 4.091 | 3.636 | 1.591 | 3.636 | 43.409 | 2.727 | 7.727 | 5.227 |
| **TMMS0220** | 65.241 | 2.500 | 12.500 | 15.682 | 11.136 | 14.432 | 21.477 | 21.591 | 15.000 | 26.818 | 35.909 |
| **TMMS0279** | 53.877 | 0.909 | 11.705 | 38.409 | 15.227 | 23.750 | 36.932 | 8.636 | 12.614 | 53.636 | 60.682 |
| **TMMS0283** | 35.963 | 7.273 | 23.864 | 26.364 | 9.205 | 6.591 | 21.477 | 12.386 | 31.136 | 35.568 | 28.068 |
| **TMMS0290** | 26.203 | 0.909 | 2.045 | 3.409 | 18.068 | 6.136 | 84.773 | 1.136 | 2.955 | 21.477 | 90.909 |
| **TMMS0296** | 72.995 | 2.955 | 12.727 | 5.909 | 13.750 | 5.909 | 27.273 | 37.273 | 15.682 | 19.659 | 33.182 |

| | Mean mid-channel canopy density (%) | Mean canopy cover > 0.3m DBH | Mean canopy cover <= 0.3m DBH | Mean woody mid-layer cover | Mean herbaceous mid-layer cover | Mean woody ground-layer cover | Mean herbaceous ground-layer cover | Mean exposed soil | Mean riparian veg canopy cover | Mean riparian veg mid-layer cover | Mean riparian veg ground cover |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **XCDENMID** | **XCL** | **XCS** | **XMW** | **XMH** | **XGW** | **XGH** | **XGB** | **XC** | **XM** | **XG** |
| **TMMS0381** | 96.390 | 3.636 | 10.909 | 35.795 | 14.091 | 23.750 | 26.705 | 8.977 | 14.545 | 49.886 | 50.455 |
| **TMMS0391** | 53.476 | 12.955 | 15.682 | 15.909 | 6.818 | 5.909 | 12.273 | 38.977 | 28.636 | 22.727 | 18.182 |
| **TMMS0437** | 9.358 | 1.591 | 3.636 | 4.318 | 4.545 | 4.091 | 87.500 | 4.091 | 5.227 | 8.864 | 91.591 |
| **TMMS1865** | 79.679 | 3.182 | 4.773 | 3.864 | 6.364 | 4.545 | 20.682 | 43.068 | 7.955 | 10.227 | 25.227 |
| **TMMS3195** | 8.690 | 0.000 | 0.000 | 1.136 | 1.364 | 0.455 | 87.500 | 5.909 | 0.000 | 2.500 | 87.955 |
| **TMMS3962** | 85.027 | 12.727 | 23.182 | 17.841 | 5.455 | 5.455 | 5.455 | 62.273 | 35.909 | 23.295 | 10.909 |
| **VGMS00002** | 88.770 | 2.500 | 6.364 | 3.864 | 5.455 | 6.136 | 14.659 | 12.159 | 8.864 | 9.318 | 20.795 |
| **VGMS00004** | 61.364 | 17.386 | 13.864 | 41.023 | 4.205 | 28.636 | 15.114 | 19.091 | 31.250 | 45.227 | 43.750 |
| **VGMS00016** | 78.342 | 0.682 | 1.364 | 6.591 | 5.227 | 6.818 | 6.136 | 45.568 | 2.045 | 11.818 | 12.955 |
| **VGMS00018** | 90.642 | 5.909 | 17.955 | 40.000 | 2.955 | 14.318 | 0.909 | 6.136 | 23.864 | 42.955 | 15.227 |
| **VGMS00022** | 73.930 | 14.886 | 20.114 | 17.955 | 18.295 | 16.477 | 13.750 | 8.864 | 35.000 | 36.250 | 30.227 |
| **VGMS00034** | 92.112 | 28.182 | 31.364 | 28.182 | 4.773 | 11.818 | 5.000 | 13.977 | 59.545 | 32.955 | 16.818 |
| **VGMS00037** | 64.037 | 6.705 | 26.477 | 17.500 | 18.295 | 9.886 | 16.136 | 15.455 | 33.182 | 35.795 | 26.023 |
| **VGMS00044** | 87.433 | 3.182 | 5.455 | 33.864 | 1.818 | 14.545 | 15.795 | 32.614 | 8.636 | 35.682 | 30.341 |
| **VGMS00048** | 60.829 | 1.364 | 1.364 | 4.091 | 4.318 | 4.773 | 8.182 | 5.455 | 2.727 | 8.409 | 12.955 |
| **VGMS00080** | 88.235 | 6.591 | 16.136 | 13.636 | 15.000 | 7.727 | 6.364 | 19.432 | 22.727 | 28.636 | 14.091 |
| **VGMS00109** | 77.941 | 16.591 | 20.568 | 42.614 | 0.455 | 57.273 | 3.864 | 15.227 | 37.159 | 43.068 | 61.136 |
| **VGMS00112** | 94.118 | 3.182 | 13.409 | 28.523 | 31.705 | 18.068 | 17.386 | 10.455 | 16.591 | 60.227 | 35.455 |
| **VGMS00121** | 62.834 | 26.932 | 11.364 | 19.773 | 16.250 | 12.045 | 15.682 | 8.636 | 38.295 | 36.023 | 27.727 |
| **VGMS00124** | 77.005 | 5.455 | 12.273 | 26.364 | 4.205 | 12.273 | 8.182 | 33.409 | 17.727 | 30.568 | 20.455 |
| **VGMS00126** | 95.321 | 10.227 | 14.773 | 31.932 | 22.273 | 9.091 | 10.455 | 10.682 | 25.000 | 54.205 | 19.545 |
| **VGMS00128** | 93.048 | 4.773 | 23.977 | 28.523 | 51.818 | 18.409 | 49.886 | 7.159 | 28.750 | 80.341 | 68.295 |
| **VGMS00162** | 96.791 | 6.136 | 30.795 | 26.818 | 11.705 | 18.523 | 5.000 | 28.182 | 36.932 | 38.523 | 23.523 |
| **VGMS00177** | 89.973 | 27.955 | 40.455 | 63.977 | 68.295 | 26.136 | 25.682 | 2.273 | 68.409 | 132.273 | 51.818 |
| **VGMS00191** | 86.497 | 28.636 | 9.432 | 54.773 | 1.591 | 9.318 | 1.591 | 45.795 | 38.068 | 56.364 | 10.909 |
| **VGMS00206** | 85.695 | 14.659 | 4.091 | 6.136 | 10.114 | 4.205 | 33.068 | 2.727 | 18.750 | 16.250 | 37.273 |
| **VGMS00210** | 35.294 | 1.591 | 3.636 | 4.545 | 6.591 | 3.182 | 26.932 | 19.432 | 5.227 | 11.136 | 30.114 |
| **VGMS00247** | 70.321 | 2.273 | 6.250 | 24.886 | 0.000 | 9.886 | 66.250 | 12.841 | 8.523 | 24.886 | 76.136 |
| **VGMS00252** | 83.422 | 7.273 | 8.182 | 10.227 | 0.455 | 6.136 | 3.636 | 27.500 | 15.455 | 10.682 | 9.773 |
| **VGMS00255** | 65.508 | 11.364 | 12.614 | 15.568 | 15.568 | 13.750 | 13.409 | 5.227 | 23.977 | 31.136 | 27.159 |
| **VGMS00277** | 72.892 | 0.682 | 2.273 | 4.545 | 3.864 | 6.364 | 6.705 | 33.864 | 2.955 | 8.409 | 13.068 |
| **VGMS00306** | 75.000 | 9.432 | 12.955 | 7.614 | 26.250 | 6.932 | 16.477 | 1.364 | 22.386 | 33.864 | 23.409 |
| **VGMS00320** | 70.856 | 19.318 | 35.227 | 33.295 | 7.273 | 10.682 | 34.091 | 20.568 | 54.545 | 40.568 | 44.773 |
| **VGMS00380** | 88.369 | 25.000 | 31.477 | 40.795 | 0.000 | 20.909 | 0.000 | 44.318 | 56.477 | 40.795 | 20.909 |

| | Mean mid-channel canopy density (%) | Mean canopy cover > 0.3m DBH | Mean canopy cover <= 0.3m DBH | Mean woody mid-layer cover | Mean herbaceous mid-layer cover | Mean woody ground-layer cover | Mean herbaceous ground-layer cover | Mean exposed soil | Mean riparian veg canopy cover | Mean riparian veg mid-layer cover | Mean riparian veg ground cover |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **XCDENMID** | **XCL** | **XCS** | **XMW** | **XMH** | **XGW** | **XGH** | **XGB** | **XC** | **XM** | **XG** |
| **VGMS00387** | 77.807 | 14.432 | 48.636 | 54.432 | 64.318 | 29.432 | 35.227 | 0.227 | 63.068 | 118.750 | 64.659 |
| **VGMS00418** | 94.118 | 20.114 | 12.500 | 37.955 | 1.818 | 21.932 | 14.432 | 55.341 | 32.614 | 39.773 | 36.364 |
| **VGMS00433** | 97.460 | 4.091 | 20.227 | 33.295 | 24.091 | 30.568 | 25.227 | 25.000 | 24.318 | 57.386 | 55.795 |
| **VGMS00444** | 34.759 | 0.227 | 14.659 | 39.432 | 1.818 | 24.205 | 40.568 | 32.045 | 14.886 | 41.250 | 64.773 |
| **VGMS00447** | 70.989 | 3.182 | 9.205 | 7.159 | 9.091 | 1.364 | 17.955 | 0.682 | 12.386 | 16.250 | 19.318 |
| **VGMS00450** | 47.193 | 2.045 | 10.341 | 10.227 | 23.182 | 4.318 | 8.523 | 13.182 | 12.386 | 33.409 | 12.841 |
| **VGMS00511** | 96.390 | 8.182 | 22.500 | 42.841 | 29.659 | 21.364 | 17.500 | 12.955 | 30.682 | 72.500 | 38.864 |
| **VGMS00515** | 85.963 | 11.591 | 11.364 | 10.000 | 27.045 | 4.886 | 22.841 | 2.955 | 22.955 | 37.045 | 27.727 |
| **VGMS00558** | 78.877 | 4.545 | 31.136 | 34.432 | 23.409 | 35.909 | 23.068 | 30.909 | 35.682 | 57.841 | 58.977 |
| **VGMS00575** | 84.091 | 1.136 | 7.045 | 19.432 | 14.773 | 15.000 | 35.000 | 4.659 | 8.182 | 34.205 | 50.000 |
| **SSMS0001** | 96.658 | 29.318 | 70.909 | 24.545 | 7.727 | 2.500 | 2.841 | 0.227 | 100.227 | 32.273 | 5.341 |
| **SSMS0002** | 96.791 | 13.068 | 17.727 | 26.364 | 15.227 | 12.841 | 15.909 | 19.773 | 30.795 | 41.591 | 28.750 |
| **SSMS0008** | 57.219 | 1.818 | 11.591 | 17.614 | 0.909 | 3.864 | 3.864 | 33.864 | 13.409 | 18.523 | 7.727 |
| **SSMS0010** | 33.021 | 1.136 | 4.545 | 3.409 | 25.455 | 3.409 | 40.341 | 67.727 | 5.682 | 28.864 | 43.750 |
| **SSMS0014** | 95.187 | 2.273 | 61.477 | 17.614 | 10.909 | 6.818 | 4.432 | 0.455 | 63.750 | 28.523 | 11.250 |
| **SSMS0028** | 94.786 | 20.114 | 27.045 | 16.818 | 16.818 | 16.818 | 18.636 | 36.023 | 47.159 | 33.636 | 35.455 |
| **SSMS0029** | 60.829 | 6.136 | 2.273 | 0.909 | 0.000 | 11.250 | 35.909 | 5.682 | 8.409 | 0.909 | 47.159 |
| **SSMS0031** | 90.775 | 4.318 | 11.023 | 11.932 | 11.932 | 11.932 | 11.932 | 38.636 | 15.341 | 23.864 | 23.864 |
| **SSMS0033** | 0.802 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 87.500 | 25.795 | 0.000 | 0.000 | 87.500 |
| **SSMS0035** | 86.364 | 9.432 | 32.045 | 30.341 | 31.250 | 21.591 | 20.000 | 45.341 | 41.477 | 61.591 | 41.591 |
| **SSMS0037** | 88.503 | 4.205 | 9.773 | 38.750 | 9.205 | 11.932 | 3.636 | 27.727 | 13.977 | 47.955 | 15.568 |
| **SSMS0038** | 83.155 | 7.955 | 4.318 | 39.432 | 6.932 | 11.705 | 6.932 | 24.886 | 12.273 | 46.364 | 18.636 |
| **SSMS0044** | 93.850 | 9.545 | 32.386 | 26.705 | 25.227 | 30.000 | 25.568 | 25.795 | 41.932 | 51.932 | 55.568 |
| **SSMS0051** | 96.524 | 12.273 | 74.205 | 52.045 | 36.023 | 1.818 | 7.273 | 0.682 | 86.477 | 88.068 | 9.091 |
| **SSMS0053** | 91.578 | 4.318 | 4.545 | 8.182 | 5.000 | 11.136 | 8.636 | 18.068 | 8.864 | 13.182 | 19.773 |
| **SSMS0057** | 94.251 | 0.909 | 3.409 | 4.545 | 4.318 | 2.955 | 5.227 | 3.864 | 4.318 | 8.864 | 8.182 |
| **SSMS0059** | 89.706 | 3.182 | 15.455 | 22.500 | 10.682 | 2.955 | 12.955 | 21.250 | 18.636 | 33.182 | 15.909 |
| **SSMS0073** | 75.401 | 9.091 | 0.909 | 30.455 | 3.409 | 13.864 | 5.000 | 40.341 | 10.000 | 33.864 | 18.864 |
| **SSMS0078** | 38.102 | 0.682 | 4.773 | 12.614 | 0.000 | 14.432 | 40.341 | 47.500 | 5.455 | 12.614 | 54.773 |
| **SSMS0094** | 93.583 | 24.773 | 43.409 | 48.750 | 7.159 | 36.477 | 25.000 | 20.455 | 68.182 | 55.909 | 61.477 |
| **SSMS0105** | 96.123 | 2.273 | 2.727 | 5.455 | 10.000 | 4.318 | 6.364 | 22.273 | 5.000 | 15.455 | 10.682 |
| **SSMS0126** | 60.963 | 3.409 | 8.409 | 14.432 | 3.636 | 2.727 | 23.750 | 27.273 | 11.818 | 18.068 | 26.477 |
| **SSMS0129** | 75.668 | 6.364 | 21.023 | 31.364 | 0.000 | 30.227 | 10.114 | 4.773 | 27.386 | 31.364 | 40.341 |
| **SSMS0133** | 24.198 | 2.955 | 28.295 | 36.477 | 11.477 | 14.545 | 40.568 | 10.682 | 31.250 | 47.955 | 55.114 |

| | Mean mid-channel canopy density (%) | Mean canopy cover > 0.3m DBH | Mean canopy cover <= 0.3m DBH | Mean woody mid-layer cover | Mean herbaceous mid-layer cover | Mean woody ground-layer cover | Mean herbaceous ground-layer cover | Mean exposed soil | Mean riparian veg canopy cover | Mean riparian veg mid-layer cover | Mean riparian veg ground cover |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **XCDENMID** | **XCL** | **XCS** | **XMW** | **XMH** | **XGW** | **XGH** | **XGB** | **XC** | **XM** | **XG** |
| **SSMS0144** | 73.128 | 1.818 | 10.795 | 14.091 | 6.364 | 7.045 | 32.614 | 3.864 | 12.614 | 20.455 | 39.659 |
| **SSMS0149** | 58.289 | 20.227 | 23.409 | 23.068 | 10.455 | 15.568 | 54.091 | 7.045 | 43.636 | 33.523 | 69.659 |
| **SSMS0150** | 83.155 | 0.909 | 1.818 | 2.500 | 3.636 | 3.864 | 15.682 | 33.182 | 2.727 | 6.136 | 19.545 |
| **SSMS0157** | 93.316 | 15.568 | 21.023 | 58.295 | 0.000 | 6.818 | 0.000 | 18.182 | 36.591 | 58.295 | 6.818 |
| **SSMS0175** | 91.043 | 12.841 | 28.295 | 30.455 | 30.455 | 25.455 | 25.455 | 19.432 | 41.136 | 60.909 | 50.909 |
| **SSMS0191** | 72.861 | 7.273 | 8.182 | 24.545 | 7.386 | 19.773 | 41.250 | 10.114 | 15.455 | 31.932 | 61.023 |
| **SSMS0193** | 95.053 | 1.591 | 2.273 | 12.727 | 3.864 | 3.864 | 3.409 | 26.705 | 3.864 | 16.591 | 7.273 |
| **SSMS0199** | 79.679 | 12.614 | 60.341 | 40.568 | 8.636 | 3.636 | 2.955 | 2.500 | 72.955 | 49.205 | 6.591 |
| **SSMS0213** | 65.107 | 3.750 | 7.159 | 30.795 | 6.364 | 16.477 | 8.068 | 40.341 | 10.909 | 37.159 | 24.545 |
| **SSMS0351** | 46.791 | 8.409 | 17.045 | 30.227 | 4.545 | 18.864 | 24.886 | 25.000 | 25.455 | 34.773 | 43.750 |
| **SSMS0408** | 98.663 | 7.614 | 14.091 | 17.273 | 1.364 | 11.818 | 16.477 | 42.727 | 21.705 | 18.636 | 28.295 |
| **SSMS0411** | 77.139 | 10.000 | 25.795 | 20.455 | 22.841 | 19.205 | 23.750 | 23.636 | 35.795 | 43.295 | 42.955 |
| **SSMS0447** | 90.374 | 20.909 | 46.250 | 64.545 | 10.795 | 38.864 | 32.614 | 10.341 | 67.159 | 75.341 | 71.477 |
| **SSMS1000** | 99.332 | 6.364 | 7.955 | 16.136 | 0.455 | 8.750 | 19.659 | 50.682 | 14.318 | 16.591 | 28.409 |
| **SSMS4173** | 21.390 | 2.727 | 4.545 | 5.682 | 10.114 | 2.955 | 51.136 | 15.568 | 7.273 | 15.795 | 54.091 |
| **SSMS4330** | 81.150 | 12.045 | 10.000 | 45.568 | 39.545 | 30.114 | 27.386 | 51.136 | 22.045 | 85.114 | 57.500 |
| **RENP0008** | 95.588 | 17.841 | 35.114 | 28.864 | 6.136 | 28.295 | 1.818 | 17.386 | 52.955 | 35.000 | 30.114 |
| **RENP0012** | 89.439 | 4.659 | 19.432 | 16.818 | 3.182 | 5.568 | 11.023 | 14.091 | 24.091 | 20.000 | 16.591 |
| **RENP0016** | 57.487 | 4.318 | 16.818 | 18.977 | 0.455 | 26.364 | 2.500 | 25.455 | 21.136 | 19.432 | 28.864 |
| **RENP0028** | 98.128 | 12.727 | 33.523 | 20.455 | 22.727 | 16.477 | 20.682 | 12.841 | 46.250 | 43.182 | 37.159 |
| **RENP0047** | 99.599 | 16.250 | 40.341 | 45.455 | 42.500 | 5.909 | 5.909 | 5.000 | 56.591 | 87.955 | 11.818 |
| **RENP0052** | 90.775 | 8.182 | 15.682 | 27.955 | 17.614 | 24.773 | 26.250 | 17.159 | 23.864 | 45.568 | 51.023 |
| **RENP0054** | 100.000 | 57.500 | 87.500 | 57.500 | 57.500 | 5.000 | 5.000 | 0.000 | 145.000 | 115.000 | 10.000 |
| **RENP0055** | 99.465 | 21.818 | 19.091 | 20.114 | 18.636 | 14.432 | 7.727 | 30.000 | 40.909 | 38.750 | 22.159 |
| **RENP0075** | 72.059 | 20.341 | 34.886 | 31.477 | 2.500 | 20.795 | 21.477 | 29.091 | 55.227 | 33.977 | 42.273 |
| **RENP0092** | 80.882 | 13.523 | 23.295 | 18.295 | 9.886 | 2.500 | 21.477 | 13.068 | 36.818 | 28.182 | 23.977 |
| **RENP0095** | 100.000 | 11.591 | 25.227 | 31.477 | 30.000 | 31.364 | 42.727 | 20.455 | 36.818 | 61.477 | 74.091 |
| **RENP0096** | 68.850 | 7.614 | 17.273 | 27.386 | 10.000 | 9.773 | 18.409 | 37.727 | 24.886 | 37.386 | 28.182 |
| **RENP0097** | 90.909 | 28.295 | 35.000 | 38.864 | 5.000 | 12.841 | 5.909 | 16.818 | 63.295 | 43.864 | 18.750 |
| **RENP100** | 72.861 | 1.818 | 11.136 | 17.159 | 18.523 | 12.386 | 40.909 | 19.432 | 12.955 | 35.682 | 53.295 |
| **RENP0108** | 98.396 | 15.568 | 51.591 | 42.727 | 0.682 | 32.955 | 2.273 | 15.568 | 67.159 | 43.409 | 35.227 |
| **RENP0110** | 99.465 | 9.318 | 77.955 | 47.841 | 9.886 | 2.955 | 2.955 | 5.455 | 87.273 | 57.727 | 5.909 |
| **RENP0112** | 92.513 | 40.568 | 34.091 | 20.114 | 7.273 | 10.455 | 16.591 | 5.909 | 74.659 | 27.386 | 27.045 |
| **RENP0128** | 29.144 | 0.000 | 1.364 | 3.409 | 19.545 | 1.818 | 32.955 | 29.545 | 1.364 | 22.955 | 34.773 |

| | Mean mid-channel canopy density (%) | Mean canopy cover > 0.3m DBH | Mean canopy cover <= 0.3m DBH | Mean woody mid-layer cover | Mean herbaceous mid-layer cover | Mean woody ground-layer cover | Mean herbaceous ground-layer cover | Mean exposed soil | Mean riparian veg canopy cover | Mean riparian veg mid-layer cover | Mean riparian veg ground cover |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **XCDENMID** | **XCL** | **XCS** | **XMW** | **XMH** | **XGW** | **XGH** | **XGB** | **XC** | **XM** | **XG** |
| **RENP0132** | 99.465 | 8.409 | 35.909 | 29.432 | 0.455 | 34.432 | 0.909 | 7.500 | 44.318 | 29.886 | 35.341 |
| **RENP0139** | 90.909 | 24.659 | 43.864 | 46.136 | 25.568 | 5.000 | 5.000 | 1.818 | 68.523 | 71.705 | 10.000 |
| **RENP0144** | 85.294 | 5.909 | 26.364 | 34.205 | 14.205 | 19.886 | 18.409 | 15.795 | 32.273 | 48.409 | 38.295 |
| **RENP0187** | 97.326 | 7.955 | 21.023 | 33.750 | 29.432 | 35.000 | 27.614 | 5.000 | 28.977 | 63.182 | 62.614 |
| **RENP0192** | 98.128 | 1.364 | 5.909 | 16.818 | 13.864 | 18.864 | 21.250 | 20.227 | 7.273 | 30.682 | 40.114 |
| **RENP0203** | 95.722 | 20.000 | 40.909 | 37.045 | 34.091 | 26.705 | 28.182 | 17.727 | 60.909 | 71.136 | 54.886 |
| **RENP0228** | 95.053 | 20.000 | 21.705 | 48.864 | 48.864 | 49.432 | 49.432 | 4.318 | 41.705 | 97.727 | 98.864 |
| **RENP0240** | 88.503 | 14.318 | 34.091 | 8.864 | 6.136 | 3.864 | 6.477 | 25.227 | 48.409 | 15.000 | 10.341 |
| **RENP0251** | 95.053 | 20.682 | 48.182 | 30.227 | 18.636 | 9.318 | 19.205 | 3.409 | 68.864 | 48.864 | 28.523 |
| **RENP0287** | 99.733 | 18.977 | 26.705 | 23.636 | 0.000 | 15.000 | 0.000 | 24.886 | 45.682 | 23.636 | 15.000 |
| **RENP0368** | 95.588 | 7.273 | 34.886 | 30.000 | 16.250 | 35.909 | 35.568 | 6.477 | 42.159 | 46.250 | 71.477 |
| **RENP0375** | 81.417 | 24.205 | 23.068 | 10.455 | 6.818 | 8.068 | 43.295 | 22.500 | 47.273 | 17.273 | 51.364 |
| **RENP0443** | 94.251 | 4.773 | 12.614 | 21.705 | 21.932 | 22.841 | 24.659 | 27.045 | 17.386 | 43.636 | 47.500 |
| **RENP0511** | 68.717 | 3.750 | 28.750 | 28.636 | 19.432 | 2.955 | 14.091 | 11.250 | 32.500 | 48.068 | 17.045 |
| **RENP1524** | 99.599 | 21.705 | 32.045 | 25.455 | 12.273 | 20.114 | 1.136 | 28.182 | 53.750 | 37.727 | 21.250 |
| **RENP2991** | 86.230 | 17.159 | 28.750 | 51.591 | 0.000 | 21.932 | 0.000 | 6.364 | 45.909 | 51.591 | 21.932 |
| **RENP5612** | 85.027 | 0.227 | 7.045 | 16.250 | 55.682 | 8.977 | 43.977 | 3.636 | 7.273 | 71.932 | 52.955 |
| **RENP7308** | 94.652 | 9.773 | 44.545 | 57.045 | 22.841 | 24.659 | 21.364 | 3.182 | 54.318 | 79.886 | 46.023 |
| **RENP9611** | 94.118 | 20.568 | 63.750 | 68.182 | 17.955 | 27.614 | 26.705 | 0.682 | 84.318 | 86.136 | 54.318 |
| **RENP9757** | 48.529 | 0.000 | 0.455 | 12.045 | 12.955 | 19.545 | 19.545 | 4.545 | 0.455 | 25.000 | 39.091 |
| **RENP12892** | 27.575 | 0.682 | 5.341 | 12.273 | 16.477 | 5.227 | 15.341 | 19.091 | 6.023 | 28.750 | 20.568 |
| **RENP15048** | 37.701 | 1.136 | 2.045 | 5.682 | 1.364 | 58.864 | 58.864 | 11.364 | 3.182 | 7.045 | 117.727 |
| **RCA02** | 3.209 | 0.000 | 0.000 | 12.917 | 3.750 | 28.750 | 87.500 | 0.000 | 0.000 | 16.667 | 116.250 |
| **RCA08** | 46.925 | 1.667 | 5.000 | 85.000 | 85.000 | 85.000 | 85.000 | 0.417 | 6.667 | 170.000 | 170.000 |
| **RCA22** | 6.551 | 3.750 | 20.000 | 42.083 | 21.458 | 59.375 | 77.500 | 0.000 | 23.750 | 63.542 | 136.875 |
| **RCA23** | 50.802 | 8.542 | 29.167 | 67.292 | 67.292 | 77.500 | 77.500 | 0.417 | 37.708 | 134.583 | 155.000 |
| **RCA30** | 37.299 | 0.000 | 0.000 | 6.667 | 2.083 | 14.375 | 87.500 | 0.000 | 0.000 | 8.750 | 101.875 |
| **RCA31** | 51.738 | 0.000 | 38.750 | 87.500 | 82.500 | 60.000 | 51.875 | 1.667 | 38.750 | 170.000 | 111.875 |
| **RCA44** | 51.070 | 0.000 | 13.333 | 85.000 | 64.792 | 62.083 | 56.667 | 0.000 | 13.333 | 149.792 | 118.750 |
| **RCA48** | 42.914 | 0.417 | 4.167 | 64.792 | 59.375 | 82.500 | 80.000 | 0.417 | 4.583 | 124.167 | 162.500 |
| **RCA49** | 42.647 | 0.000 | 5.000 | 62.500 | 65.000 | 85.000 | 87.500 | 0.000 | 5.000 | 127.500 | 172.500 |
| **RCA50** | 37.166 | 0.000 | 0.417 | 45.000 | 45.000 | 82.500 | 85.000 | 0.000 | 0.417 | 90.000 | 167.500 |
| **RCA52** | 39.572 | 0.417 | 6.667 | 70.000 | 70.000 | 85.000 | 85.000 | 0.000 | 7.083 | 140.000 | 170.000 |
| **RCA53** | 37.567 | 0.000 | 2.083 | 75.000 | 75.000 | 85.000 | 85.000 | 0.000 | 2.083 | 150.000 | 170.000 |

| | Mean mid-channel canopy density (%) | Mean canopy cover > 0.3m DBH | Mean canopy cover <= 0.3m DBH | Mean woody mid-layer cover | Mean herbaceous mid-layer cover | Mean woody ground-layer cover | Mean herbaceous ground-layer cover | Mean exposed soil | Mean riparian veg canopy cover | Mean riparian veg mid-layer cover | Mean riparian veg ground cover |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **XCDENMID** | **XCL** | **XCS** | **XMW** | **XMH** | **XGW** | **XGH** | **XGB** | **XC** | **XM** | **XG** |
| **RCA57** | 39.572 | 1.667 | 11.458 | 47.500 | 41.875 | 85.000 | 87.500 | 0.000 | 13.125 | 89.375 | 172.500 |
| **RCA58** | 27.807 | 0.000 | 0.417 | 16.042 | 15.625 | 40.625 | 87.500 | 0.000 | 0.417 | 31.667 | 128.125 |
| **RCA59** | 8.422 | 0.000 | 0.000 | 6.250 | 0.000 | 59.583 | 87.500 | 0.000 | 0.000 | 6.250 | 147.083 |
| **RCA60** | 0.000 | 0.000 | 0.000 | 2.083 | 3.750 | 23.125 | 87.500 | 0.000 | 0.000 | 5.833 | 110.625 |
| **RCA62** | 46.257 | 0.000 | 2.917 | 11.667 | 8.333 | 35.833 | 35.833 | 0.000 | 2.917 | 20.000 | 71.667 |
| **RCA64** | 46.658 | 2.500 | 6.667 | 46.667 | 33.125 | 75.000 | 67.292 | 0.000 | 9.167 | 79.792 | 142.292 |
| **RCA65** | 51.738 | 0.833 | 0.000 | 67.292 | 67.292 | 70.417 | 70.417 | 2.083 | 0.833 | 134.583 | 140.833 |
| **RCA66** | 50.401 | 0.417 | 21.042 | 64.583 | 64.583 | 80.000 | 74.792 | 0.000 | 21.458 | 129.167 | 154.792 |
| **RCA67** | 49.198 | 0.000 | 36.250 | 62.917 | 57.708 | 77.500 | 65.000 | 0.000 | 36.250 | 120.625 | 142.500 |
| **RCA68** | 40.775 | 0.000 | 2.083 | 45.625 | 48.333 | 72.292 | 72.292 | 2.083 | 2.083 | 93.958 | 144.583 |
| **RCA69** | 39.171 | 0.000 | 2.083 | 67.500 | 59.167 | 79.792 | 74.792 | 0.417 | 2.083 | 126.667 | 154.583 |
| **RCA70** | 45.053 | 0.000 | 13.333 | 75.000 | 72.500 | 77.500 | 77.500 | 0.000 | 13.333 | 147.500 | 155.000 |
| **RCA71** | 47.727 | 0.000 | 5.000 | 72.500 | 72.500 | 82.500 | 82.500 | 0.000 | 5.000 | 145.000 | 165.000 |
| **RCA72** | 10.561 | 0.000 | 0.417 | 58.958 | 56.250 | 64.375 | 64.375 | 2.083 | 0.417 | 115.208 | 128.750 |
| **RCA73** | 35.963 | 0.000 | 2.083 | 68.125 | 65.417 | 69.792 | 67.083 | 1.667 | 2.083 | 133.542 | 136.875 |
| **RCA74** | 32.754 | 0.000 | 1.667 | 57.083 | 62.500 | 87.500 | 87.500 | 0.000 | 1.667 | 119.583 | 175.000 |
| **RCA90** | 27.941 | 0.000 | 4.167 | 39.583 | 53.125 | 85.000 | 87.500 | 0.000 | 4.167 | 92.708 | 172.500 |

**Table 2.7.** In-stream cover variables.

| | Prop. Areal cover filamentous algae | Prop. Areal cover aquatic macrophytes | Prop. Areal cover large woody debris | Prop. Areal cover brush | Prop. Areal cover live trees | Prop. Areal cover leaves bank | Prop. Areal cover undercut banks | Prop. Areal cover boulders |
|---|---|---|---|---|---|---|---|---|
| | **XFC_ALG** | **XFC_AQM** | **XFC_LWD** | **XFC_BRS** | **XFC_ROT** | **XFC_LEB** | **XFC_UCB** | **XFC_RCK** |
| **TMMS0003** | 4.091 | 0.000 | 3.182 | 8.636 | 7.273 | 26.818 | 0.909 | 0.000 |
| **TMMS0007** | 0.000 | 0.000 | 30.227 | 40.682 | 4.545 | 71.818 | 1.818 | 0.000 |
| **TMMS0009** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 19.773 | 0.000 | 2.273 |
| **TMMS0027** | 15.909 | 0.000 | 0.000 | 0.000 | 0.000 | 5.682 | 0.000 | 79.091 |
| **TMMS0028** | 34.773 | 0.000 | 0.455 | 5.909 | 9.091 | 23.182 | 1.364 | 2.273 |
| **TMMS0033** | 0.000 | 3.182 | 1.364 | 4.091 | 8.636 | 11.591 | 10.000 | 4.545 |
| **TMMS0040** | 0.000 | 0.000 | 0.000 | 0.000 | 0.455 | 0.909 | 0.000 | 55.682 |
| **TMMS0043** | 0.000 | 1.364 | 3.182 | 3.636 | 4.091 | 15.682 | 3.636 | 15.682 |
| **TMMS0058** | 5.000 | 0.000 | 0.000 | 0.000 | 0.000 | 17.045 | 0.000 | 7.273 |
| **TMMS0072** | 0.000 | 0.000 | 0.000 | 0.909 | 3.182 | 44.091 | 15.227 | 2.273 |
| **TMMS0082** | 0.000 | 0.000 | 1.364 | 12.955 | 0.455 | 79.545 | 0.455 | 0.000 |
| **TMMS0088** | 20.682 | 3.636 | 0.909 | 1.818 | 5.909 | 22.045 | 1.818 | 43.636 |
| **TMMS0090** | 0.000 | 0.000 | 0.000 | 0.000 | 0.455 | 3.182 | 2.727 | 44.773 |
| **TMMS0091** | 31.364 | 0.000 | 1.364 | 2.727 | 4.545 | 5.909 | 0.455 | 34.318 |
| **TMMS0106** | 0.909 | 0.000 | 8.636 | 24.318 | 15.909 | 43.864 | 27.273 | 0.000 |
| **TMMS0119** | 0.000 | 0.000 | 1.364 | 7.727 | 20.000 | 42.500 | 0.000 | 0.000 |
| **TMMS0126** | 0.000 | 0.000 | 2.273 | 12.045 | 10.682 | 23.636 | 2.727 | 3.636 |
| **TMMS0133** | 0.909 | 0.000 | 22.955 | 27.955 | 8.182 | 22.500 | 5.000 | 0.000 |
| **TMMS0134** | 5.000 | 0.000 | 0.000 | 0.000 | 1.364 | 10.227 | 9.773 | 32.273 |
| **TMMS0137** | 0.000 | 0.000 | 18.182 | 28.636 | 5.000 | 6.818 | 0.455 | 0.000 |
| **TMMS0159** | 23.182 | 0.455 | 2.273 | 5.909 | 11.818 | 24.773 | 6.818 | 44.091 |
| **TMMS0171** | 13.636 | 0.000 | 0.000 | 0.000 | 6.818 | 0.000 | 5.909 | 87.500 |
| **TMMS0178** | 1.818 | 0.909 | 6.818 | 6.818 | 7.727 | 39.773 | 8.182 | 7.727 |
| **TMMS0183** | 0.000 | 0.000 | 7.727 | 6.818 | 30.227 | 36.136 | 10.000 | 8.409 |
| **TMMS0187** | 0.000 | 0.000 | 0.000 | 4.091 | 5.909 | 20.682 | 5.000 | 30.909 |
| **TMMS0193** | 0.000 | 0.455 | 7.727 | 13.182 | 20.227 | 1.818 | 7.045 | 0.000 |
| **TMMS0209** | 0.000 | 0.000 | 0.455 | 8.182 | 35.682 | 32.045 | 5.000 | 0.000 |
| **TMMS0214** | 0.000 | 0.000 | 0.455 | 10.455 | 6.818 | 10.000 | 0.909 | 0.000 |
| **TMMS0220** | 0.000 | 0.000 | 0.000 | 1.818 | 2.273 | 20.227 | 0.000 | 31.591 |
| **TMMS0279** | 0.000 | 0.000 | 0.000 | 1.364 | 5.455 | 5.000 | 2.727 | 68.864 |
| **TMMS0283** | 5.227 | 0.000 | 0.000 | 0.000 | 0.000 | 0.455 | 0.455 | 25.455 |
| **TMMS0290** | 0.000 | 1.818 | 0.000 | 0.000 | 4.545 | 3.182 | 2.273 | 0.000 |
| **TMMS0296** | 0.000 | 0.455 | 1.818 | 5.455 | 2.727 | 7.727 | 1.364 | 56.364 |

| | Prop. Areal cover filamentous algae | Prop. Areal cover aquatic macrophytes | Prop. Areal cover large woody debris | Prop. Areal cover brush | Prop. Areal cover live trees | Prop. Areal cover leaves bank | Prop. Areal cover undercut banks | Prop. Areal cover boulders |
|---|---|---|---|---|---|---|---|---|
| | **XFC_ALG** | **XFC_AQM** | **XFC_LWD** | **XFC_BRS** | **XFC_ROT** | **XFC_LEB** | **XFC_UCB** | **XFC_RCK** |
| **TMMS0381** | 0.000 | 6.136 | 5.909 | 6.364 | 47.727 | 23.636 | 1.364 | 0.000 |
| **TMMS0391** | 0.000 | 0.000 | 0.000 | 0.000 | 0.909 | 1.364 | 0.909 | 13.636 |
| **TMMS0437** | 29.545 | 15.455 | 0.909 | 0.455 | 12.273 | 0.000 | 0.000 | 0.000 |
| **TMMS1865** | 0.909 | 0.000 | 19.091 | 22.727 | 8.182 | 27.955 | 0.000 | 0.000 |
| **TMMS3195** | 6.364 | 21.818 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **TMMS3962** | 0.000 | 0.000 | 0.000 | 0.000 | 0.455 | 47.500 | 0.000 | 1.818 |
| **VGMS00002** | 0.000 | 0.000 | 0.000 | 3.636 | 17.727 | 81.818 | 0.000 | 0.000 |
| **VGMS00004** | 5.682 | 0.000 | 4.545 | 10.909 | 21.364 | 18.409 | 5.000 | 2.727 |
| **VGMS00016** | 0.000 | 0.000 | 1.364 | 10.000 | 18.409 | 30.227 | 3.182 | 0.909 |
| **VGMS00018** | 0.000 | 0.000 | 1.364 | 5.909 | 7.045 | 15.455 | 0.455 | 48.182 |
| **VGMS00022** | 0.000 | 0.000 | 0.455 | 2.273 | 17.727 | 13.409 | 2.727 | 20.909 |
| **VGMS00034** | 0.000 | 0.000 | 23.864 | 23.182 | 20.909 | 70.682 | 0.000 | 9.773 |
| **VGMS00037** | 0.000 | 0.000 | 10.682 | 23.636 | 13.864 | 17.727 | 2.273 | 0.000 |
| **VGMS00044** | 0.000 | 0.000 | 7.500 | 8.182 | 9.091 | 28.182 | 7.273 | 0.000 |
| **VGMS00048** | 0.000 | 2.727 | 4.545 | 8.182 | 18.636 | 0.909 | 0.455 | 0.000 |
| **VGMS00080** | 0.000 | 0.000 | 3.182 | 7.273 | 8.636 | 5.000 | 14.318 | 37.955 |
| **VGMS00109** | 0.000 | 0.000 | 2.273 | 6.818 | 14.091 | 5.000 | 17.500 | 0.000 |
| **VGMS00112** | 0.000 | 0.000 | 1.364 | 22.500 | 8.636 | 30.227 | 3.636 | 2.273 |
| **VGMS00121** | 0.000 | 0.000 | 16.136 | 23.636 | 14.545 | 42.727 | 15.682 | 2.273 |
| **VGMS00124** | 0.000 | 0.000 | 5.000 | 9.545 | 15.227 | 21.818 | 10.000 | 20.682 |
| **VGMS00126** | 0.000 | 8.864 | 0.909 | 9.091 | 20.682 | 40.682 | 5.000 | 8.409 |
| **VGMS00128** | 0.000 | 0.000 | 0.000 | 11.136 | 23.409 | 35.000 | 0.455 | 0.000 |
| **VGMS00162** | 0.000 | 0.000 | 12.955 | 25.000 | 24.318 | 31.364 | 5.909 | 0.000 |
| **VGMS00177** | 0.000 | 0.909 | 34.318 | 41.818 | 15.682 | 8.636 | 0.000 | 0.455 |
| **VGMS00191** | 0.000 | 0.000 | 2.727 | 11.818 | 7.727 | 12.955 | 6.364 | 1.364 |
| **VGMS00206** | 0.000 | 2.273 | 0.000 | 5.455 | 3.636 | 73.409 | 1.364 | 0.000 |
| **VGMS00210** | 0.000 | 0.000 | 8.864 | 1.818 | 7.273 | 2.273 | 0.455 | 2.273 |
| **VGMS00247** | 0.000 | 0.000 | 0.000 | 0.455 | 26.591 | 0.000 | 0.000 | 0.000 |
| **VGMS00252** | 0.000 | 0.000 | 1.364 | 8.182 | 19.545 | 11.364 | 9.318 | 0.455 |
| **VGMS00255** | 0.000 | 0.455 | 0.000 | 1.818 | 7.727 | 7.045 | 0.455 | 22.500 |
| **VGMS00277** | 0.000 | 0.000 | 9.773 | 4.091 | 2.727 | 10.455 | 3.636 | 5.455 |
| **VGMS00306** | 0.000 | 0.000 | 3.182 | 4.545 | 0.909 | 5.455 | 8.636 | 1.818 |
| **VGMS00320** | 0.000 | 0.000 | 0.455 | 2.273 | 4.545 | 16.591 | 5.909 | 0.000 |
| **VGMS00380** | 0.000 | 0.000 | 0.000 | 12.273 | 7.273 | 14.091 | 5.000 | 0.000 |

| | Prop. Areal cover filamentous algae | Prop. Areal cover aquatic macrophytes | Prop. Areal cover large woody debris | Prop. Areal cover brush | Prop. Areal cover live trees | Prop. Areal cover leaves bank | Prop. Areal cover undercut banks | Prop. Areal cover boulders |
|---|---|---|---|---|---|---|---|---|
| | **XFC_ALG** | **XFC_AQM** | **XFC_LWD** | **XFC_BRS** | **XFC_ROT** | **XFC_LEB** | **XFC_UCB** | **XFC_RCK** |
| **VGMS00387** | 0.000 | 0.000 | 33.182 | 40.682 | 30.909 | 15.909 | 14.318 | 12.500 |
| **VGMS00418** | 0.000 | 0.000 | 2.273 | 5.000 | 6.818 | 12.955 | 16.136 | 12.500 |
| **VGMS00433** | 0.000 | 0.000 | 12.045 | 20.909 | 15.227 | 19.545 | 13.636 | 5.227 |
| **VGMS00444** | 0.000 | 0.000 | 0.455 | 4.545 | 6.364 | 6.364 | 3.182 | 23.864 |
| **VGMS00447** | 0.000 | 0.000 | 8.864 | 1.818 | 4.545 | 2.273 | 19.318 | 2.727 |
| **VGMS00450** | 0.000 | 1.364 | 0.000 | 0.909 | 2.727 | 4.545 | 0.455 | 71.591 |
| **VGMS00511** | 0.000 | 0.000 | 1.818 | 14.091 | 20.682 | 22.500 | 1.818 | 13.182 |
| **VGMS00515** | 0.000 | 0.000 | 0.000 | 2.273 | 6.364 | 10.000 | 9.318 | 0.455 |
| **VGMS00558** | 0.000 | 0.000 | 0.000 | 5.455 | 4.091 | 39.091 | 3.182 | 23.182 |
| **VGMS00575** | 0.000 | 2.273 | 0.909 | 3.182 | 8.636 | 8.182 | 0.909 | 46.591 |
| **SSMS0001** | 0.000 | 0.000 | 21.591 | 52.045 | 70.909 | 23.636 | 12.955 | 12.955 |
| **SSMS0002** | 1.364 | 0.000 | 4.545 | 4.545 | 9.091 | 37.955 | 2.273 | 17.727 |
| **SSMS0008** | 0.000 | 4.091 | 0.455 | 3.182 | 18.864 | 42.045 | 9.318 | 9.091 |
| **SSMS0010** | 21.818 | 65.682 | 0.000 | 15.227 | 4.545 | 1.818 | 1.364 | 0.000 |
| **SSMS0014** | 0.000 | 0.000 | 0.909 | 7.273 | 7.273 | 18.864 | 15.000 | 1.818 |
| **SSMS0028** | 0.455 | 4.545 | 1.818 | 6.818 | 4.091 | 7.727 | 0.909 | 0.000 |
| **SSMS0029** | 0.000 | 3.182 | 3.636 | 7.273 | 14.545 | 4.545 | 21.364 | 5.909 |
| **SSMS0031** | 0.455 | 12.955 | 0.000 | 3.636 | 17.727 | 22.500 | 0.000 | 0.000 |
| **SSMS0033** | 13.864 | 4.545 | 0.000 | 0.000 | 4.545 | 0.000 | 0.000 | 0.000 |
| **SSMS0035** | 0.000 | 0.000 | 3.182 | 3.636 | 44.318 | 33.409 | 20.227 | 71.818 |
| **SSMS0037** | 0.000 | 0.909 | 0.000 | 2.727 | 2.727 | 6.818 | 1.818 | 0.000 |
| **SSMS0038** | 0.000 | 0.000 | 0.909 | 29.091 | 9.545 | 8.864 | 19.773 | 0.000 |
| **SSMS0044** | 0.000 | 0.000 | 0.455 | 12.273 | 13.636 | 35.000 | 2.273 | 9.773 |
| **SSMS0051** | 0.000 | 0.455 | 25.455 | 37.955 | 62.727 | 40.909 | 6.818 | 0.000 |
| **SSMS0053** | 0.000 | 0.000 | 0.000 | 1.364 | 2.727 | 23.636 | 0.455 | 5.227 |
| **SSMS0057** | 0.000 | 2.727 | 5.000 | 6.364 | 9.545 | 16.136 | 0.909 | 0.455 |
| **SSMS0059** | 0.000 | 0.000 | 9.091 | 21.818 | 11.364 | 29.091 | 10.000 | 0.000 |
| **SSMS0073** | 0.000 | 0.000 | 0.000 | 15.227 | 5.455 | 1.818 | 3.636 | 0.000 |
| **SSMS0078** | 0.455 | 1.818 | 1.364 | 2.273 | 6.364 | 1.818 | 0.455 | 10.455 |
| **SSMS0094** | 0.000 | 0.000 | 1.818 | 12.273 | 7.727 | 17.045 | 0.455 | 36.591 |
| **SSMS0105** | 0.000 | 0.000 | 1.364 | 16.591 | 7.273 | 14.091 | 1.364 | 20.227 |
| **SSMS0126** | 0.000 | 0.909 | 3.182 | 11.818 | 13.636 | 5.000 | 3.182 | 0.000 |
| **SSMS0129** | 3.182 | 0.000 | 1.818 | 11.818 | 14.091 | 11.364 | 9.545 | 0.000 |
| **SSMS0133** | 29.091 | 0.000 | 0.000 | 0.909 | 0.909 | 0.455 | 2.273 | 30.227 |

| | Prop. Areal cover filamentous algae | Prop. Areal cover aquatic macrophytes | Prop. Areal cover large woody debris | Prop. Areal cover brush | Prop. Areal cover live trees | Prop. Areal cover leaves bank | Prop. Areal cover undercut banks | Prop. Areal cover boulders |
|---|---|---|---|---|---|---|---|---|
| | **XFC_ALG** | **XFC_AQM** | **XFC_LWD** | **XFC_BRS** | **XFC_ROT** | **XFC_LEB** | **XFC_UCB** | **XFC_RCK** |
| **SSMS0144** | 0.455 | 1.818 | 0.909 | 13.864 | 19.545 | 22.500 | 22.045 | 0.000 |
| **SSMS0149** | 2.273 | 0.000 | 7.955 | 12.955 | 7.500 | 1.818 | 0.455 | 13.636 |
| **SSMS0150** | 0.000 | 0.455 | 4.091 | 14.318 | 20.682 | 5.455 | 8.636 | 11.591 |
| **SSMS0157** | 0.000 | 0.000 | 0.000 | 15.227 | 4.091 | 55.000 | 1.364 | 0.000 |
| **SSMS0175** | 1.364 | 0.000 | 0.909 | 4.545 | 12.273 | 8.636 | 1.364 | 40.682 |
| **SSMS0191** | 0.000 | 0.000 | 6.591 | 12.955 | 3.636 | 11.136 | 0.909 | 4.091 |
| **SSMS0193** | 0.000 | 0.000 | 4.545 | 11.364 | 3.636 | 15.227 | 0.909 | 0.000 |
| **SSMS0199** | 0.000 | 0.000 | 2.273 | 30.455 | 26.136 | 63.636 | 17.727 | 0.909 |
| **SSMS0213** | 0.000 | 0.000 | 0.455 | 6.818 | 6.364 | 1.364 | 15.909 | 3.182 |
| **SSMS0351** | 0.455 | 0.000 | 2.727 | 10.455 | 0.909 | 14.091 | 0.000 | 5.909 |
| **SSMS0408** | 0.000 | 4.091 | 1.364 | 14.091 | 26.818 | 15.909 | 0.455 | 0.455 |
| **SSMS0411** | 0.455 | 0.455 | 0.000 | 6.364 | 12.273 | 15.909 | 2.273 | 24.545 |
| **SSMS0447** | 0.000 | 0.000 | 4.091 | 8.636 | 5.000 | 17.727 | 3.182 | 27.273 |
| **SSMS1000** | 0.000 | 2.273 | 2.273 | 12.273 | 34.318 | 6.818 | 7.273 | 0.455 |
| **SSMS4173** | 32.500 | 3.182 | 0.455 | 1.364 | 0.455 | 0.000 | 0.000 | 38.636 |
| **SSMS4330** | 18.409 | 0.000 | 0.000 | 0.455 | 0.455 | 22.500 | 4.545 | 35.227 |
| **RENP0008** | 0.000 | 12.500 | 0.000 | 3.636 | 30.909 | 39.773 | 20.682 | 0.455 |
| **RENP0012** | 0.909 | 0.000 | 0.000 | 4.091 | 10.000 | 25.455 | 0.455 | 18.182 |
| **RENP0016** | 0.000 | 0.000 | 2.273 | 4.545 | 4.545 | 4.545 | 5.909 | 9.091 |
| **RENP0028** | 1.364 | 0.000 | 0.909 | 7.727 | 13.636 | 19.545 | 1.364 | 29.773 |
| **RENP0047** | 0.000 | 0.000 | 3.636 | 9.773 | 37.727 | 53.636 | 5.682 | 0.455 |
| **RENP0052** | 0.000 | 0.000 | 1.818 | 12.500 | 5.000 | 28.409 | 0.000 | 0.000 |
| **RENP0054** | 0.000 | 0.000 | 0.000 | 25.000 | 57.500 | 57.500 | 1.818 | 0.000 |
| **RENP0055** | 0.000 | 0.000 | 7.273 | 10.000 | 19.091 | 14.091 | 13.636 | 2.273 |
| **RENP0075** | 0.000 | 0.455 | 0.455 | 4.091 | 4.545 | 10.455 | 5.000 | 0.909 |
| **RENP0092** | 0.000 | 0.455 | 0.455 | 3.182 | 14.091 | 12.273 | 0.909 | 2.727 |
| **RENP0095** | 0.000 | 0.000 | 5.909 | 20.682 | 21.364 | 47.727 | 0.909 | 0.000 |
| **RENP0096** | 0.000 | 0.000 | 3.182 | 16.591 | 10.682 | 18.409 | 15.000 | 1.364 |
| **RENP0097** | 0.000 | 0.000 | 0.909 | 5.909 | 6.364 | 15.909 | 6.818 | 2.273 |
| **RENP100** | 6.818 | 11.591 | 0.909 | 4.091 | 25.455 | 14.318 | 0.455 | 3.182 |
| **RENP0108** | 0.000 | 5.909 | 0.000 | 9.545 | 25.000 | 23.182 | 10.455 | 16.591 |
| **RENP0110** | 0.000 | 0.000 | 0.455 | 3.182 | 24.773 | 11.364 | 5.455 | 20.227 |
| **RENP0112** | 0.000 | 0.000 | 2.273 | 6.818 | 14.091 | 27.273 | 6.818 | 0.000 |
| **RENP0128** | 0.000 | 37.727 | 0.455 | 3.182 | 43.636 | 0.000 | 0.000 | 0.000 |

| | Prop. Areal cover filamentous algae | Prop. Areal cover aquatic macrophytes | Prop. Areal cover large woody debris | Prop. Areal cover brush | Prop. Areal cover live trees | Prop. Areal cover leaves bank | Prop. Areal cover undercut banks | Prop. Areal cover boulders |
|---|---|---|---|---|---|---|---|---|
| | **XFC_ALG** | **XFC_AQM** | **XFC_LWD** | **XFC_BRS** | **XFC_ROT** | **XFC_LEB** | **XFC_UCB** | **XFC_RCK** |
| **RENP0132** | 0.000 | 3.636 | 0.000 | 3.636 | 25.000 | 24.318 | 14.091 | 3.636 |
| **RENP0139** | 0.000 | 0.000 | 1.364 | 11.591 | 26.818 | 17.727 | 5.000 | 0.000 |
| **RENP0144** | 0.455 | 0.000 | 2.727 | 6.364 | 6.818 | 60.455 | 3.182 | 15.455 |
| **RENP0187** | 0.000 | 0.000 | 0.000 | 8.182 | 13.409 | 21.364 | 5.000 | 0.000 |
| **RENP0192** | 0.000 | 0.000 | 0.000 | 5.000 | 4.545 | 3.636 | 26.818 | 0.000 |
| **RENP0203** | 0.000 | 0.000 | 0.909 | 5.000 | 17.727 | 13.636 | 7.273 | 4.091 |
| **RENP0228** | 0.000 | 0.000 | 0.909 | 5.455 | 44.318 | 14.773 | 8.636 | 13.864 |
| **RENP0240** | 0.000 | 0.000 | 1.364 | 18.864 | 20.000 | 54.091 | 0.000 | 0.000 |
| **RENP0251** | 0.000 | 0.000 | 11.364 | 16.591 | 12.273 | 8.182 | 0.455 | 26.591 |
| **RENP0287** | 0.000 | 5.455 | 1.364 | 10.455 | 27.955 | 42.727 | 8.636 | 0.000 |
| **RENP0368** | 0.455 | 0.455 | 0.909 | 15.227 | 31.364 | 39.545 | 15.909 | 0.000 |
| **RENP0375** | 0.000 | 0.000 | 0.000 | 2.727 | 5.000 | 20.227 | 1.364 | 0.000 |
| **RENP0443** | 0.000 | 0.455 | 0.455 | 4.545 | 5.000 | 5.000 | 7.727 | 0.000 |
| **RENP0511** | 0.000 | 0.000 | 12.273 | 13.636 | 17.273 | 15.909 | 4.091 | 4.091 |
| **RENP1524** | 0.000 | 0.909 | 0.455 | 17.045 | 25.000 | 42.727 | 19.545 | 12.500 |
| **RENP2991** | 0.000 | 3.182 | 0.455 | 2.727 | 27.955 | 22.500 | 21.364 | 10.455 |
| **RENP5612** | 0.000 | 0.455 | 2.727 | 2.727 | 20.682 | 2.273 | 8.636 | 5.227 |
| **RENP7308** | 0.000 | 0.000 | 2.273 | 17.727 | 12.273 | 49.545 | 1.364 | 18.864 |
| **RENP9611** | 0.000 | 0.000 | 3.182 | 18.864 | 22.500 | 29.091 | 3.182 | 5.909 |
| **RENP9757** | 0.000 | 0.000 | 0.000 | 0.000 | 5.000 | 0.000 | 0.000 | 0.000 |
| **RENP12892** | 10.682 | 31.364 | 0.000 | 1.364 | 11.818 | 1.818 | 1.364 | 0.455 |
| **RENP15048** | 0.000 | 0.000 | 0.000 | 0.000 | 51.591 | 0.000 | 0.455 | 0.000 |
| **RCA02** | 6.136 | 4.091 | 0.455 | 0.000 | 23.409 | 0.000 | 5.909 | 7.273 |
| **RCA08** | 0.000 | 0.455 | 17.727 | 0.000 | 7.500 | 39.318 | 11.818 | 0.455 |
| **RCA22** | 0.000 | 16.591 | 2.273 | 0.000 | 4.545 | 1.364 | 5.455 | 42.273 |
| **RCA23** | 0.000 | 0.455 | 19.545 | 0.000 | 28.182 | 36.591 | 1.364 | 10.000 |
| **RCA30** | 0.000 | 5.909 | 7.273 | 0.000 | 11.136 | 0.455 | 11.136 | 22.273 |
| **RCA31** | 0.000 | 2.273 | 10.682 | 0.000 | 19.545 | 11.136 | 14.091 | 14.545 |
| **RCA44** | 0.000 | 6.364 | 23.636 | 0.000 | 16.591 | 14.773 | 4.091 | 17.727 |
| **RCA48** | 0.909 | 2.273 | 20.682 | 0.000 | 36.818 | 4.545 | 9.318 | 28.409 |
| **RCA49** | 0.000 | 0.909 | 17.045 | 0.000 | 29.318 | 26.591 | 15.909 | 3.182 |
| **RCA50** | 0.000 | 0.455 | 7.045 | 0.000 | 34.091 | 2.273 | 45.000 | 23.636 |
| **RCA52** | 0.000 | 1.818 | 15.909 | 0.000 | 29.318 | 6.364 | 2.727 | 42.273 |
| **RCA53** | 0.000 | 0.000 | 6.818 | 0.000 | 20.682 | 1.818 | 10.227 | 39.773 |

| | Prop. Areal cover filamentous algae | Prop. Areal cover aquatic macrophytes | Prop. Areal cover large woody debris | Prop. Areal cover brush | Prop. Areal cover live trees | Prop. Areal cover leaves bank | Prop. Areal cover undercut banks | Prop. Areal cover boulders |
|---|---|---|---|---|---|---|---|---|
| | **XFC_ALG** | **XFC_AQM** | **XFC_LWD** | **XFC_BRS** | **XFC_ROT** | **XFC_LEB** | **XFC_UCB** | **XFC_RCK** |
| **RCA57** | 7.045 | 11.364 | 5.682 | 0.000 | 31.136 | 2.273 | 25.455 | 7.727 |
| **RCA58** | 0.455 | 5.909 | 0.000 | 0.000 | 17.727 | 0.000 | 8.182 | 2.273 |
| **RCA59** | 5.000 | 15.909 | 0.000 | 0.000 | 28.182 | 0.000 | 0.000 | 2.273 |
| **RCA60** | 7.727 | 25.455 | 0.000 | 0.000 | 22.500 | 0.000 | 0.000 | 0.000 |
| **RCA62** | 3.182 | 17.727 | 31.364 | 0.000 | 30.682 | 47.727 | 14.773 | 0.000 |
| **RCA64** | 0.909 | 5.909 | 11.364 | 0.000 | 14.773 | 4.091 | 31.136 | 14.773 |
| **RCA65** | 0.455 | 7.273 | 4.545 | 0.000 | 23.636 | 7.273 | 0.455 | 4.545 |
| **RCA66** | 0.000 | 4.091 | 11.818 | 0.000 | 20.682 | 15.909 | 9.318 | 31.364 |
| **RCA67** | 0.000 | 5.455 | 3.182 | 0.000 | 8.182 | 12.955 | 5.455 | 28.409 |
| **RCA68** | 0.000 | 0.455 | 18.864 | 0.000 | 19.545 | 12.955 | 9.545 | 11.364 |
| **RCA69** | 0.000 | 0.909 | 1.364 | 0.000 | 20.682 | 0.000 | 5.000 | 47.727 |
| **RCA70** | 0.000 | 3.182 | 24.318 | 0.000 | 36.818 | 1.818 | 7.727 | 13.182 |
| **RCA71** | 0.000 | 2.727 | 17.727 | 0.000 | 28.409 | 39.318 | 8.409 | 23.409 |
| **RCA72** | 0.000 | 2.273 | 1.364 | 0.000 | 14.091 | 7.273 | 0.000 | 23.636 |
| **RCA73** | 0.000 | 0.000 | 1.364 | 0.000 | 25.455 | 0.000 | 8.864 | 47.727 |
| **RCA74** | 0.000 | 5.000 | 3.182 | 0.000 | 28.409 | 0.000 | 7.273 | 25.227 |
| **RCA90** | 4.545 | 13.409 | 11.818 | 0.000 | 34.091 | 13.636 | 14.091 | 9.545 |

**Table 2.8.** Water quality variables.

| | Dissolved oxygen (mg/L) | pH | Turbidity (UNT) | Conductivity (µS/cm) | TDS (mg/L) | Water temperature (°C) | Total Nitrogen (mg/L) | Total Phosphorus (mg/L) |
|---|---|---|---|---|---|---|---|---|
| **TM00003** | 8.3 | 7.50 | 15.31 | 34.0 | 22 | 16.3 | 0.063 | 0.008 |
| **TM00007** | 7.1 | 7.30 | 9.45 | 43.0 | 28 | 17.1 | 0.091 | 0.012 |
| **TM00009** | 6.6 | 7.40 | 1.56 | 108.0 | 71 | 15.2 | 0.063 | 0.017 |
| **TM00027** | 8.9 | 8.70 | 2.31 | 33.0 | 20 | 15.5 | 0.077 | 0.001 |
| **TM00028** | 10.6 | 8.50 | 2.04 | 128.0 | 83 | 14.9 | 0.084 | 0.032 |
| **TM00033** | 7.6 | 7.80 | 9.92 | 53.0 | 34 | 15.5 | NA | 0.014 |
| **TM00040** | 5.7 | 7.60 | 3.68 | 60.0 | 39 | 15.6 | 0.077 | 0.020 |
| **TM00043** | 10.4 | 8.50 | 9.77 | 34.0 | 22 | 16.0 | 0.098 | 0.004 |
| **TM00058** | 5.1 | 7.60 | 3.04 | 36.0 | 27 | 18.4 | 0.070 | 0.024 |
| **TM00072** | 10.1 | 8.10 | 1.86 | 199.0 | 130 | 15.3 | 0.063 | 0.018 |
| **TM00082** | 6.9 | 7.50 | 3.88 | 135.0 | 88 | 16.2 | 0.070 | 0.020 |
| **TM00088** | 10.2 | 7.50 | 4.76 | 71.0 | 52 | 19.3 | 0.077 | 0.033 |
| **TM00090** | 9.9 | 7.40 | 4.48 | 30.0 | 19 | 16.8 | 0.070 | 0.021 |
| **TM00091** | 10 | 8.50 | 4.23 | 79.0 | 51 | 19.4 | 0.049 | 0.033 |
| **TM00106** | 2.3 | 7.20 | 3.05 | 39.0 | 30 | 16.2 | 0.056 | 0.023 |
| **TM00119** | 7.3 | 7.20 | 15.36 | 67.0 | 44 | 19.3 | 0.070 | 0.031 |
| **TM00126** | 0.8 | 7.50 | 6.72 | 63.0 | 41 | 16.6 | 0.133 | 0.059 |
| **TM00133** | 7.6 | 8.00 | 1.33 | 15.0 | 11 | 17.0 | 0.084 | 0.037 |
| **TM00134** | 9 | 7.60 | 2.41 | 44.0 | 29 | 18.0 | 0.098 | 0.001 |
| **TM00137** | 6.3 | 7.70 | 9.58 | 153.0 | 99 | 14.7 | 0.063 | 0.001 |
| **TM00159** | 10.1 | 8.30 | 1.49 | 42.0 | 27 | 19.0 | 0.056 | 0.008 |
| **TM00171** | 10.7 | 7.70 | 1.74 | 41.0 | 29 | 21.2 | 0.077 | 0.008 |
| **TM00178** | 8.4 | 7.20 | 2.45 | 136.0 | 101 | 18.7 | 0.077 | 0.028 |
| **TM00183** | 5.8 | 6.40 | 3.41 | 22.0 | 17 | 16.2 | 0.091 | 0.001 |
| **TM00187** | 9.3 | 6.80 | 4.22 | 22.0 | 17 | 17.4 | 0.056 | 0.020 |
| **TM00193** | 9.6 | 7.80 | 5.90 | 20.0 | 13 | 16.9 | 0.077 | 0.029 |
| **TM00209** | 6.9 | 7.30 | 4.45 | 26.0 | 17 | 16.3 | 0.063 | 0.025 |
| **TM00214** | 5 | 8.00 | 54.40 | 72.0 | 47 | 16.3 | 0.070 | 0.042 |
| **TM00220** | 9.9 | 8.30 | 1.60 | 219.0 | 142 | 16.5 | 0.140 | 0.022 |
| **TM00279** | 10.9 | 7.70 | 3.22 | 75.0 | 57 | 17.6 | 0.077 | 0.020 |
| **TM00283** | 11.7 | 8.10 | 3.66 | 30.0 | 20 | 18.7 | 0.112 | 0.001 |
| **TM00290** | 6.8 | 7.50 | 5.91 | 28.0 | 18 | 15.0 | 0.084 | 0.022 |
| **TM00296** | 10.3 | 7.80 | 4.07 | 50.0 | 37 | 18.4 | 0.070 | 0.020 |
| **TM00381** | 7.4 | 6.90 | 1.57 | 7.0 | 6 | 14.2 | 0.042 | 0.017 |
| **TM00391** | 9 | 8.30 | 10.02 | 39.0 | 25 | 19.6 | 0.084 | 0.028 |

| | Dissolved oxygen (mg/L) | pH | Turbidity (UNT) | Conductivity (µS/cm) | TDS (mg/L) | Water temperature (°C) | Total Nitrogen (mg/L) | Total Phosphorus (mg/L) |
|---|---|---|---|---|---|---|---|---|
| **TM00437** | 4.3 | 7.50 | 8.54 | 72.0 | 46 | 18.5 | 0.063 | 0.020 |
| **TM01865** | 1.8 | 7.30 | 7.49 | 90.0 | 69 | 16.9 | 0.056 | 0.026 |
| **TM03195** | 11.5 | 7.70 | 6.17 | 21.0 | 14 | 22.2 | 0.070 | 0.011 |
| **TM03962** | 5.7 | 7.50 | 3.04 | 47.0 | 0 | 19.0 | 0.091 | 0.015 |
| **VG00002** | 6.1 | 7.10 | 3.51 | 20.0 | 29 | 20.3 | 0.098 | 0.004 |
| **VG00004** | NA | 7.12 | 3.98 | 74.0 | 18 | 21.5 | 0.133 | 0.015 |
| **VG00016** | 8 | 6.98 | 3.43 | 45.0 | 50 | 19.3 | 0.119 | 0.009 |
| **VG00018** | 8.3 | 7.60 | 5.89 | 25.0 | 28 | 19.4 | 0.077 | 0.008 |
| **VG00022** | 16.3 | 6.49 | 10.00 | 44.0 | 37 | 18.7 | 0.126 | 0.077 |
| **VG00034** | 8.4 | 7.30 | 2.08 | 42.0 | 30 | 19.8 | 0.126 | 0.010 |
| **VG00037** | 14.7 | 6.96 | 3.36 | 25.0 | 2 | 22.6 | 0.112 | 0.022 |
| **VG00044** | 7.4 | 8.10 | 3.15 | 35.0 | 5 | 21.9 | 0.133 | 0.015 |
| **VG00048** | 7.9 | NA | 21.90 | 15.0 | 11 | 21.4 | 0.126 | 0.031 |
| **VG00080** | 4.2 | 9.30 | 6.15 | 16.0 | 17 | 22.1 | 0.105 | 0.016 |
| **VG00109** | 7.9 | 7.10 | 6.85 | 32.0 | 4 | 21.7 | 0.084 | 0.009 |
| **VG00112** | 3.8 | 9.10 | 4.88 | 23.0 | 25 | 20.4 | 0.063 | 0.014 |
| **VG00121** | 8.4 | 6.15 | 3.94 | 30.0 | NA | 20.5 | 0.224 | 0.003 |
| **VG00124** | 6.6 | 6.41 | NA | 32.0 | NA | 20.2 | 0.112 | 0.016 |
| **VG00126** | 6.7 | 9.60 | 5.42 | 18.0 | 20 | 20.2 | 0.112 | 0.015 |
| **VG00128** | 15.6 | 7.67 | 3.80 | 22.0 | 16 | 19.9 | 0.182 | 0.018 |
| **VG00162** | 15.6 | 7.44 | 6.88 | 23.0 | 17 | 19.4 | 0.091 | 0.001 |
| **VG00177** | 6.7 | 7.26 | 7.92 | 49.0 | 35 | 21.2 | 0.126 | 0.011 |
| **VG00191** | 8.1 | 7.02 | 5.55 | 78.0 | 19 | 21.3 | 0.182 | 0.038 |
| **VG00206** | 6.4 | 7.60 | NA | 63.0 | NA | 21.6 | 0.070 | 0.016 |
| **VG00210** | 8.2 | 8.05 | 1.29 | 56.0 | NA | 19.6 | 0.063 | 0.011 |
| **VG00247** | 7.6 | 6.98 | 2.35 | 35.0 | 5 | 21.8 | 0.119 | 0.015 |
| **VG00252** | 9.2 | 7.09 | 3.50 | 52.0 | NA | 19.9 | 0.084 | 0.007 |
| **VG00255** | 7.9 | 7.26 | 10.82 | 37.0 | 26 | 20.7 | 0.091 | 0.022 |
| **VG00277** | 10.4 | 7.50 | 3.46 | 44.0 | 49 | 19.7 | 0.126 | 0.005 |
| **VG00306** | 7.8 | 7.24 | 3.19 | 38.0 | NA | 19.1 | 0.126 | 0.002 |
| **VG00320** | 8.4 | NA | 4.71 | 30.0 | NA | 20.0 | 0.119 | 0.008 |
| **VG00380** | 8.6 | 7.26 | 3.17 | 50.0 | 10 | 20.5 | 0.133 | 0.010 |
| **VG00387** | 7.6 | 7.06 | 9.87 | 38.0 | 27 | 21.0 | 0.154 | 0.127 |
| **VG00418** | 9.1 | 7.40 | 1.63 | 65.0 | 15 | 19.5 | 0.119 | 0.008 |
| **VG00433** | 8.5 | 7.40 | 4.49 | 2.0 | 14 | 20.4 | 0.112 | 0.008 |
| **VG00444** | 8.4 | 7.31 | 2.86 | 58.0 | 13 | 19.8 | 0.112 | 0.009 |
| **VG00447** | 7.6 | 7.00 | 18.50 | 43.0 | NA | 20.8 | 0.126 | 0.058 |

| | Dissolved oxygen (mg/L) | pH | Turbidity (UNT) | Conductivity (µS/cm) | TDS (mg/L) | Water temperature (°C) | Total Nitrogen (mg/L) | Total Phosphorus (mg/L) |
|---|---|---|---|---|---|---|---|---|
| **VG00450** | 8.6 | 6.82 | 3.47 | 40.0 | NA | 18.9 | 0.084 | 0.004 |
| **VG00511** | 6.4 | 9.80 | 9.17 | 41.0 | 44 | 21.7 | 0.070 | 0.021 |
| **VG00515** | 8.6 | 7.50 | 4.20 | 55.0 | NA | 20.7 | 0.105 | NA |
| **VG00558** | 9.3 | 7.80 | 3.58 | 31.0 | 24 | 16.3 | 0.119 | 0.031 |
| **VG00575** | 14 | 8.30 | 14.39 | 69.0 | 69 | 23.2 | 0.091 | 0.014 |
| **SSMS0001** | 7.3 | 7.80 | 2.10 | 8.4 | 0 | 21.5 | 0.084 | 0.005 |
| **SSMS0002** | 8.3 | 7.26 | 3.90 | 78.9 | 46.2 | 20.0 | 0.084 | 0.003 |
| **SSMS0008** | 7.2 | 7.41 | 6.83 | 67.4 | 36.9 | 19.0 | 0.098 | 0.004 |
| **SSMS0010** | 7.6 | 6.54 | 4.14 | 36.0 | 18.6 | 19.0 | 0.084 | 0.001 |
| **SSMS0014** | 7.8 | 6.20 | 1.47 | 13.5 | 4.6 | 20.9 | 0.098 | 0.001 |
| **SSMS0028** | 7.3 | 5.56 | 4.97 | 39.8 | 19.4 | 21.0 | 0.091 | 0.001 |
| **SSMS0029** | 10.1 | 7.80 | 11.90 | 69.9 | 39.5 | 22.0 | 0.077 | 0.004 |
| **SSMS0031** | 7.2 | 5.54 | 9.86 | 18.7 | 5.1 | 21.0 | 0.119 | 0.007 |
| **SSMS0033** | 8.2 | 7.67 | 15.41 | 184.9 | 109.9 | 25.0 | 0.091 | 0.004 |
| **SSMS0035** | 7.3 | 6.80 | 6.85 | 39.6 | 18.7 | 21.6 | 0.112 | 0.001 |
| **SSMS0037** | 5.5 | 6.68 | 6.19 | 96.5 | 55.6 | 21.4 | 0.098 | 0.009 |
| **SSMS0038** | 7.7 | 6.87 | 12.41 | 116.2 | 66.5 | 19.0 | 0.105 | 0.004 |
| **SSMS0044** | 7.3 | 6.36 | 4.98 | 41.6 | 19.3 | 19.0 | 0.091 | 0.003 |
| **SSMS0051** | 7 | 7.26 | 7.73 | 39.7 | 18.3 | 19.0 | 0.091 | 0.002 |
| **SSMS0053** | 8.9 | 6.82 | 2.96 | 77.9 | 13.4 | NA | 0.077 | 0.002 |
| **SSMS0057** | 6.7 | 7.11 | 3.78 | 233.0 | 145 | 20.0 | 0.105 | 0.003 |
| **SSMS0059** | 7.2 | 6.81 | 8.70 | 60.4 | 32.1 | 18.0 | 0.112 | 0.005 |
| **SSMS0073** | 6.3 | 6.78 | 4.46 | 95.1 | 56.4 | 21.5 | 0.210 | 0.022 |
| **SSMS0078** | 8.5 | 6.63 | 5.33 | 50.9 | 26.7 | 18.0 | 0.084 | 0.002 |
| **SSMS0094** | 8.3 | 6.60 | 2.45 | 24.4 | 9.4 | 24.5 | 0.077 | 0.001 |
| **SSMS0105** | 10.7 | 6.72 | 9.30 | 30.2 | 13.2 | 20.0 | 0.070 | 0.002 |
| **SSMS0126** | 7.6 | 6.86 | 7.73 | 33.5 | 15.9 | 17.0 | 0.112 | 0.003 |
| **SSMS0129** | 8 | 7.59 | 8.48 | 172.3 | 104.2 | 19.0 | 0.098 | 0.004 |
| **SSMS0133** | 10.2 | 7.66 | 3.76 | 94.0 | 53.8 | 19.0 | 0.098 | 0.003 |
| **SSMS0144** | 8.1 | 7.31 | 5.65 | 40.3 | 19.9 | 18.0 | 0.112 | 0.002 |
| **SSMS0149** | 8.8 | 7.60 | 20.90 | 58.0 | 29.5 | 20.0 | 0.077 | 0.006 |
| **SSMS0150** | 6.8 | 6.85 | 8.10 | 9.6 | 55.2 | 20.0 | 0.091 | 0.003 |
| **SSMS0157** | 7.3 | 6.57 | 4.70 | 76.9 | 35.3 | 20.0 | 0.091 | 0.345 |
| **SSMS0175** | 7.8 | 6.12 | 2.13 | 44.2 | 22.3 | 20.0 | 0.070 | 0.002 |
| **SSMS0191** | 7.5 | 6.77 | 6.08 | 45.6 | 22.6 | 18.5 | 0.126 | 0.003 |
| **SSMS0193** | 7.3 | 6.89 | 12.57 | 189.5 | 110.8 | 21.5 | 0.154 | 0.006 |
| **SSMS0199** | NA | 6.70 | 3.71 | 43.6 | 22.3 | 21.4 | 0.112 | 0.001 |

| | Dissolved oxygen (mg/L) | pH | Turbidity (UNT) | Conductivity (µS/cm) | TDS (mg/L) | Water temperature (°C) | Total Nitrogen (mg/L) | Total Phosphorus (mg/L) |
|---|---|---|---|---|---|---|---|---|
| **SSMS0213** | 8.3 | 6.65 | 7.26 | 55.3 | 28.8 | 21.9 | 0.105 | 0.001 |
| **SSMS0351** | 7.3 | 6.60 | 3.19 | 70.1 | 38.3 | 22.6 | 0.112 | 0.002 |
| **SSMS0408** | 6.8 | 7.02 | 14.19 | 29.5 | 43.3 | 20.0 | 0.091 | 0.004 |
| **SSMS0411** | 7.2 | 6.44 | 4.95 | 67.8 | 39.1 | 18.0 | 0.098 | 0.006 |
| **SSMS0447** | 11.1 | 7.03 | 3.98 | 45.8 | 24 | 20.0 | 0.098 | 0.003 |
| **SSMS1000** | 7 | 7.54 | 4.54 | 75.0 | 42.2 | 20.0 | 0.112 | 0.004 |
| **SSMS4173** | 7.6 | 7.30 | 12.93 | 131.6 | 60.3 | 20.0 | 0.154 | 0.004 |
| **SSMS4330** | 7.2 | 7.10 | 4.78 | 42.9 | 20.8 | 21.4 | 0.091 | 0.001 |
| **RENP0008** | 6.6 | 6.0 | 4.2 | 6.3 | 0.0 | 19.0 | 0.084 | 0.014 |
| **RENP0012** | 8.4 | 6.8 | 15.0 | 24.0 | 10.7 | 19.1 | 0.084 | 0.016 |
| **RENP0016** | 8.1 | 6.3 | 1.4 | 9.1 | 0.0 | 19.0 | 0.126 | 0.007 |
| **RENP0028** | 8.5 | 7.8 | 2.7 | 25.0 | 19.0 | 19.0 | 0.105 | 0.013 |
| **RENP0047** | 7.4 | 6.5 | 20.4 | 16.0 | 10.9 | 22.7 | 0.091 | 0.176 |
| **RENP0052** | 7.6 | 8.2 | 1.5 | 22.0 | 16.0 | 21.0 | 0.098 | 0.005 |
| **RENP0054** | 7.2 | 6.0 | 2.4 | 8.5 | 6.2 | 19.1 | 0.084 | 0.019 |
| **RENP0055** | 8.5 | 6.4 | 4.2 | 12.6 | 0.6 | 18.0 | 0.098 | 0.019 |
| **RENP0075** | 8.0 | 6.5 | 3.8 | 18.0 | 6.5 | 19.5 | 0.112 | 0.016 |
| **RENP0092** | 7.9 | 6.9 | 3.1 | 46.0 | 17.9 | 20.0 | 0.077 | 0.005 |
| **RENP0095** | 8.6 | 8.0 | 1.6 | 17.0 | 13.0 | 16.4 | 0.091 | 0.004 |
| **RENP0096** | 8.6 | 6.9 | 31.7 | 27.0 | 20.0 | 19.4 | 0.112 | 0.011 |
| **RENP0097** | 7.5 | 6, 7 | 4.3 | 42.0 | 25.6 | 20.7 | 0.112 | 0.007 |
| **RENP0100** | 9.0 | 7.9 | 4.9 | 21.0 | 15.0 | 19.4 | 0.112 | 0.009 |
| **RENP0108** | 6.7 | 6.5 | 6.5 | 13.5 | 3.5 | 19.0 | 0.126 | 0.017 |
| **RENP0110** | 8.1 | 6.3 | 2.7 | 14.1 | 10.1 | 26.2 | 0.098 | 0.011 |
| **RENP0112** | 6.2 | 6.3 | 7.1 | 6.7 | 4.9 | 19.1 | 0.091 | 0.015 |
| **RENP0128** | 6.7 | 7.6 | 4.6 | 29.0 | 16.2 | 20.2 | 0.084 | 0.013 |
| **RENP0132** | 8.0 | 6.5 | 2.4 | 15.7 | 2.3 | 19.0 | 0.091 | 0.011 |
| **RENP0139** | 7.7 | 6.5 | 2.5 | 13.8 | 10.1 | 19.2 | 0.098 | 0.030 |
| **RENP0144** | 7.5 | 6.6 | 1.9 | 40.0 | 15.3 | 16.7 | 0.070 | 0.018 |
| **RENP0187** | 7.6 | 8.3 | 3.2 | 29.0 | 21.0 | 19.0 | 0.084 | 0.007 |
| **RENP0192** | 8.0 | 7.6 | 9.4 | 28.0 | 16.0 | 19.3 | 0.119 | 0.045 |
| **RENP0203** | 9.4 | 5.8 | 1.3 | 28.0 | 4.7 | 17.0 | 0.084 | 0.009 |
| **RENP0228** | 8.5 | 5.8 | 3.8 | 7.9 | 5.8 | 19.4 | 0.084 | 0.009 |
| **RENP0240** | 8.1 | 5.9 | 3.4 | 16.0 | 24.8 | 19.7 | 0.112 | 0.022 |
| **RENP0251** | 8.1 | 6.5 | 4.1 | 14.0 | NA | 18.9 | 0.098 | 0.020 |
| **RENP0287** | 6.1 | 6.8 | 2.1 | 62.5 | 27.5 | 19.0 | 0.077 | 0.003 |
| **RENP0368** | 8.4 | 7.3 | 1.8 | 14.8 | 10.5 | 21.2 | 0.119 | 0.002 |

| | Dissolved oxygen (mg/L) | pH | Turbidity (UNT) | Conductivity (µS/cm) | TDS (mg/L) | Water temperature (°C) | Total Nitrogen (mg/L) | Total Phosphorus (mg/L) |
|---|---|---|---|---|---|---|---|---|
| **RENP0375** | 8.8 | 7.3 | 1.5 | 20.0 | 14.0 | 21.2 | 0.112 | 0.006 |
| **RENP0443** | 7.2 | 7.9 | 3.5 | 23.0 | 16.0 | 20.1 | 0.091 | 0.017 |
| **RENP0511** | 7.4 | 6.6 | 2.3 | 17.0 | 8.1 | 17.5 | 0.015 | 0.005 |
| **RENP1524** | 9.4 | 6.6 | 2.3 | 23.0 | 0.0 | 17.0 | 0.071 | 0.007 |
| **RENP2991** | 9.0 | 7.7 | NA | 11.8 | 10.3 | 19.3 | 0.119 | 0.019 |
| **RENP5612** | 9.5 | 7.7 | 4.0 | 11.8 | 8.6 | 19.3 | 0.091 | 0.000 |
| **RENP7308** | 6.4 | 5.8 | 1.6 | 18.0 | 11.8 | 19.1 | 0.098 | 0.008 |
| **RENP9611** | 8.0 | 6.8 | 3.0 | 11.0 | NA | 19.4 | 0.070 | 0.009 |
| **RENP9757** | 8.2 | 6.3 | 2.8 | 81.1 | 5.3 | 17.8 | 0.091 | 0.021 |
| **RENP12892** | 6.4 | 7.3 | 2.2 | 37.0 | 27.0 | 18.7 | 0.105 | 0.004 |
| **RENP15048** | 7.0 | 5.7 | 9.3 | 13.4 | 9.9 | 18.6 | 0.091 | 0.009 |
| **RCA02** | 6.7 | 6.79 | 0.27 | 1.4 | 0 | 19.3 | 0.063 | 0.002 |
| **RCA08** | 3.3 | 7.11 | 10.74 | 7.3 | 3.72 | 19.9 | 0.056 | 0.009 |
| **RCA22** | 9.2 | 6.58 | 0.71 | 1.7 | 0 | 17.7 | 0.056 | 0.005 |
| **RCA23** | 7 | 5.68 | 2.78 | 4.5 | 0 | 16.7 | 0.049 | 0.001 |
| **RCA30** | 7.6 | 6.84 | 0.43 | 2.6 | 0 | 20.3 | 0.049 | 0.006 |
| **RCA31** | 9 | 6.52 | 3.01 | 1.5 | 0.74 | 21.0 | 0.063 | 0.005 |
| **RCA44** | 8.1 | 7.92 | 5.56 | 4.3 | 2.14 | 21.3 | 0.063 | 0.003 |
| **RCA48** | 7.6 | 5.38 | 41.40 | 3.1 | 1.95 | 20.3 | 0.028 | 0.004 |
| **RCA49** | 7.6 | 5.16 | 2.46 | 0.7 | 0.28 | 20.1 | 0.056 | 0.002 |
| **RCA50** | 8.7 | 5.68 | 2.85 | 0.6 | 0.25 | 19.1 | 0.042 | 0.001 |
| **RCA52** | 8.6 | 5.22 | 1.40 | 2.5 | 1.24 | 18.2 | 0.035 | 0.001 |
| **RCA53** | 8.2 | 7.33 | 3.44 | 0.6 | 0.27 | 17.0 | 0.028 | 0.001 |
| **RCA57** | 7.6 | 8.01 | 0.26 | 2.6 | 0 | 18.4 | 0.042 | 0.001 |
| **RCA58** | 7.6 | 7.12 | 0.27 | 3.5 | 0 | 19.2 | 0.042 | 0.000 |
| **RCA59** | 7.7 | 7.43 | 0.13 | 1.9 | 0 | 19.2 | 0.077 | 0.001 |
| **RCA60** | 9.2 | 6.90 | 0.10 | 1.2 | 0 | 18.2 | 0.035 | 0.001 |
| **RCA62** | 1.8 | 7.43 | 0.96 | 6.3 | 0 | 18.7 | 0.077 | 0.010 |
| **RCA64** | 8.6 | 6.47 | 4.16 | 12.2 | 0 | 19.4 | 0.070 | 0.005 |
| **RCA65** | 7.6 | 8.40 | 2.72 | 2.7 | 1.21 | 21.3 | 0.028 | 0.000 |
| **RCA66** | 7.1 | 7.39 | 1.69 | 4.4 | 2.28 | 19.8 | 0.035 | 0.004 |
| **RCA67** | 8.2 | 7.60 | 1.13 | 4.4 | 2.31 | 20.8 | 0.042 | 0.001 |
| **RCA68** | 7.6 | 5.60 | 2.42 | 2.4 | 1.51 | 20.1 | 0.035 | 0.000 |
| **RCA69** | 7.4 | 6.60 | 5.52 | 0.7 | 0.35 | 19.9 | 0.021 | 0.001 |
| **RCA70** | 7.8 | 5.34 | 2.37 | 3.3 | 1.43 | 19.8 | 0.070 | 0.001 |
| **RCA71** | 7.5 | 6.06 | 1.09 | 2.5 | 1.24 | 18.8 | 0.035 | 0.003 |
| **RCA72** | 7.9 | 8.03 | 21.00 | 1.5 | 0.72 | 19.6 | 0.112 | 0.004 |

| | Dissolved oxygen (mg/L) | pH | Turbidity (UNT) | Conductivity (µS/cm) | TDS (mg/L) | Water temperature (°C) | Total Nitrogen (mg/L) | Total Phosphorus (mg/L) |
|---|---|---|---|---|---|---|---|---|
| **RCA73** | 8 | 7.80 | 9.82 | 1.0 | 0.5 | 21.3 | 0.021 | 0.003 |
| **RCA74** | 8.3 | 4.82 | 3.85 | 2.1 | 0.88 | 19.6 | 0.049 | 0.002 |
| **RCA90** | 9.1 | 7.94 | 4.08 | 1.8 | 0.94 | 21.2 | 0.028 | 0.004 |

**Table 2.9.** Local (LDI), catchment (DI) and integrated disturbances (IDI) indexes for each sampling site.

| | IDI | LDI | CDI |
|---|---|---|---|
| **TMMS0003** | 0.376 | 1.304 | 81.444 |
| **TMMS0007** | 0.309 | 1.212 | 57.578 |
| **TMMS0009** | 0.288 | 1.341 | 31.209 |
| **TMMS0027** | 0.285 | 0.803 | 70.705 |
| **TMMS0028** | 0.336 | 1.652 | 18.999 |
| **TMMS0033** | 0.383 | 1.728 | 49.450 |
| **TMMS0040** | 0.362 | 1.409 | 68.112 |
| **TMMS0043** | 0.448 | 1.971 | 63.846 |
| **TMMS0058** | 0.518 | 2.379 | 61.759 |
| **TMMS0072** | 0.174 | 0.121 | 51.668 |
| **TMMS0082** | 0.298 | 0.735 | 77.718 |
| **TMMS0088** | 0.154 | 0.690 | 20.567 |
| **TMMS0090** | 0.205 | 0.545 | 52.090 |
| **TMMS0091** | 0.238 | 0.803 | 52.567 |
| **TMMS0106** | 0.166 | 0.174 | 48.711 |
| **TMMS0119** | 0.331 | 1.084 | 75.238 |
| **TMMS0126** | 0.181 | 0.068 | 54.278 |
| **TMMS0133** | 0.312 | 0.879 | 77.425 |
| **TMMS0134** | 0.013 | 0.000 | 3.888 |
| **TMMS0137** | 0.375 | 1.758 | 39.087 |
| **TMMS0159** | 0.389 | 1.735 | 52.498 |
| **TMMS0171** | 0.133 | 0.000 | 39.927 |
| **TMMS0178** | 0.268 | 0.561 | 73.093 |
| **TMMS0183** | 0.274 | 0.000 | 82.174 |
| **TMMS0187** | 0.239 | 0.622 | 61.124 |
| **TMMS0193** | 0.411 | 1.462 | 86.844 |
| **TMMS0209** | 0.302 | 0.152 | 90.042 |
| **TMMS0214** | 0.487 | 1.879 | 92.779 |
| **TMMS0220** | 0.139 | 0.470 | 30.643 |
| **TMMS0279** | 0.395 | 1.448 | 80.639 |
| **TMMS0283** | 0.143 | 0.000 | 42.844 |
| **TMMS0290** | 0.561 | 2.455 | 81.583 |
| **TMMS0296** | 0.298 | 1.409 | 28.828 |
| **TMMS0381** | 0.195 | 0.409 | 53.046 |
| **TMMS0391** | 0.225 | 0.386 | 63.371 |
| **TMMS0437** | 0.379 | 1.485 | 70.709 |
| **TMMS1865** | 0.559 | 2.712 | 40.709 |
| **TMMS3195** | 0.498 | 1.970 | 91.496 |
| **TMMS3962** | 0.388 | 1.795 | 43.998 |
| **VGMS0002** | 0.705 | 2.273 | 161.538 |
| **VGMS0004** | 0.532 | 0.773 | 152.761 |
| **VGMS0016** | 0.728 | 2.357 | 166.629 |
| **VGMS0018** | 0.621 | 0.667 | 181.818 |
| **VGMS0022** | 0.605 | 0.303 | 180.645 |
| **VGMS0034** | 0.787 | 2.547 | 180.000 |
| **VGMS0037** | 0.592 | 0.834 | 170.270 |
| **VGMS0044** | 0.549 | 1.432 | 140.580 |
| **VGMS0048** | 0.722 | 2.258 | 168.852 |
| **VGMS0080** | 0.682 | 1.894 | 170.196 |
| **VGMS0109** | 0.593 | 0.826 | 170.813 |
| **VGMS0112** | 0.618 | 1.281 | 168.880 |
| **VGMS0121** | 0.568 | 0.856 | 162.353 |
| **VGMS0124** | 0.589 | 0.856 | 169.141 |
| **VGMS0126** | 0.507 | 0.227 | 151.515 |
| **VGMS0128** | 0.595 | 1.637 | 148.980 |
| **VGMS0162** | 0.648 | 1.334 | 177.184 |
| **VGMS0177** | 0.722 | 2.106 | 176.000 |
| **VGMS0191** | 0.626 | 1.046 | 176.963 |
| **VGMS0206** | 0.493 | 1.046 | 133.962 |

| | IDI | LDI | CDI |
|---|---|---|---|
| **VGMS0210** | 0.510 | 1.538 | 122.177 |
| **VGMS0247** | 0.712 | 1.834 | 182.927 |
| **VGMS0252** | 0.571 | 0.743 | 165.405 |
| **VGMS0255** | 0.537 | 0.492 | 158.333 |
| **VGMS0277** | 0.643 | 1.644 | 165.751 |
| **VGMS0306** | 0.501 | 0.977 | 138.340 |
| **VGMS0320** | 0.563 | 1.038 | 157.143 |
| **VGMS0380** | 0.520 | 0.477 | 153.361 |
| **VGMS0387** | 0.622 | 0.637 | 182.511 |
| **VGMS0418** | 0.593 | 0.796 | 171.429 |
| **VGMS0433** | 0.600 | 0.834 | 172.788 |
| **VGMS0444** | 0.617 | 1.190 | 170.875 |
| **VGMS0447** | 0.584 | 0.803 | 168.362 |
| **VGMS0450** | 0.561 | 1.243 | 151.008 |
| **VGMS0511** | 0.529 | 0.136 | 158.519 |
| **VGMS0515** | 0.502 | 0.864 | 141.288 |
| **VGMS0558** | 0.649 | 0.205 | 194.215 |
| **VGMS0575** | 0.633 | 1.750 | 158.333 |
| **SSMS0001** | 0.658 | 1.001 | 188.155 |
| **SSMS0002** | 0.511 | 0.667 | 148.103 |
| **SSMS0008** | 0.699 | 2.197 | 163.127 |
| **SSMS0010** | 0.605 | 1.250 | 165.120 |
| **SSMS0014** | 0.585 | 1.076 | 163.324 |
| **SSMS0028** | 0.615 | 0.834 | 177.653 |
| **SSMS0029** | 0.717 | 1.924 | 181.453 |
| **SSMS0031** | 0.573 | 1.917 | 127.763 |
| **SSMS0033** | 0.437 | 1.500 | 95.140 |
| **SSMS0035** | 0.451 | 0.955 | 122.604 |
| **SSMS0037** | 0.565 | 0.963 | 159.269 |
| **SSMS0038** | 0.521 | 1.129 | 140.766 |
| **SSMS0044** | 0.600 | 0.834 | 172.866 |
| **SSMS0051** | 0.584 | 0.856 | 167.434 |
| **SSMS0053** | 0.624 | 0.917 | 178.961 |
| **SSMS0057** | 0.441 | 1.399 | 102.068 |
| **SSMS0059** | 0.559 | 1.599 | 137.658 |
| **SSMS0073** | 0.746 | 2.076 | 186.029 |
| **SSMS0078** | 0.512 | 1.212 | 135.370 |
| **SSMS0094** | 0.637 | 1.334 | 173.543 |
| **SSMS0105** | 0.701 | 2.038 | 170.956 |
| **SSMS0126** | 0.671 | 2.296 | 146.854 |
| **SSMS0129** | 0.538 | 0.606 | 157.243 |
| **SSMS0133** | 0.464 | 0.000 | 139.190 |
| **SSMS0144** | 0.669 | 1.667 | 173.855 |
| **SSMS0149** | 0.502 | 1.046 | 137.045 |
| **SSMS0150** | 0.708 | 2.645 | 141.011 |
| **SSMS0157** | 0.645 | 0.993 | 184.008 |
| **SSMS0175** | 0.480 | 0.667 | 138.333 |
| **SSMS0191** | 0.444 | 0.818 | 123.959 |
| **SSMS0193** | 0.590 | 1.356 | 157.243 |
| **SSMS0199** | 0.541 | 0.788 | 155.353 |
| **SSMS0213** | 0.439 | 0.955 | 118.693 |
| **SSMS0351** | 0.468 | 0.000 | 140.345 |
| **SSMS0408** | 0.550 | 1.001 | 153.832 |
| **SSMS0411** | 0.471 | 0.667 | 135.510 |
| **SSMS0447** | 0.483 | 0.000 | 144.868 |
| **SSMS1000** | 0.607 | 1.091 | 170.033 |
| **SSMS4173** | 1.475 | 4.758 | 338.097 |
| **SSMS4330** | 1.141 | 5.046 | 159.631 |
| **RENP0008** | 0.561 | 0.637 | 163.968 |
| **RENP0012** | 0.342 | 1.697 | 13.441 |

| | IDI | LDI | CDI |
|---|---|---|---|
| **RENP0016** | 0.042 | 0.091 | 11.465 |
| **RENP0028** | 0.428 | 0.614 | 123.003 |
| **RENP0047** | 0.299 | 0.099 | 89.473 |
| **RENP0052** | 0.435 | 0.637 | 124.902 |
| **RENP0054** | 0.220 | 0.667 | 52.515 |
| **RENP0055** | 0.612 | 0.477 | 181.242 |
| **RENP0075** | 0.139 | 0.667 | 11.699 |
| **RENP0092** | 0.441 | 1.727 | 82.357 |
| **RENP0095** | 0.601 | 0.894 | 172.138 |
| **RENP0096** | 0.561 | 0.235 | 167.858 |
| **RENP0097** | 0.545 | 1.766 | 124.410 |
| **RENP0100** | 0.159 | 0.273 | 44.735 |
| **RENP0108** | 0.525 | 0.728 | 151.325 |
| **RENP0110** | 0.445 | 0.402 | 131.231 |
| **RENP0112** | 0.524 | 0.849 | 148.873 |
| **RENP0128** | 0.593 | 2.697 | 73.612 |
| **RENP0132** | 0.399 | 0.682 | 112.515 |
| **RENP0139** | 0.608 | 1.091 | 170.141 |
| **RENP0144** | 0.393 | 1.160 | 95.187 |
| **RENP0187** | 0.414 | 0.000 | 124.346 |
| **RENP0192** | 0.552 | 0.667 | 160.742 |
| **RENP0203** | 0.216 | 0.705 | 49.033 |
| **RENP0228** | 0.645 | 2.129 | 145.473 |
| **RENP0240** | 0.601 | 1.834 | 142.746 |
| **RENP0251** | 0.449 | 0.424 | 132.231 |
| **RENP0287** | 0.497 | 1.235 | 129.360 |
| **RENP0368** | 0.792 | 2.576 | 180.446 |
| **RENP0375** | 0.279 | 1.250 | 37.102 |
| **RENP0443** | 0.410 | 0.000 | 123.058 |
| **RENP0511** | 0.561 | 0.962 | 158.198 |
| **RENP1524** | 0.747 | 2.091 | 185.834 |
| **RENP2991** | 0.524 | 0.500 | 154.358 |
| **RENP5612** | 0.581 | 1.273 | 156.831 |
| **RENP7308** | 0.040 | 0.114 | 10.020 |
| **RENP9611** | 0.474 | 0.197 | 141.762 |
| **RENP9757** | 1.259 | 5.334 | 200.435 |
| **RENP12892** | 0.556 | 2.515 | 71.110 |
| **RENP15048** | 1.292 | 5.955 | 150.422 |
| **RCA02** | 0.000 | 0.000 | 0.000 |
| **RCA08** | 0.100 | 0.000 | 29.922 |
| **RCA22** | 0.000 | 0.000 | 0.000 |
| **RCA23** | 0.000 | 0.000 | 0.000 |
| **RCA30** | 0.437 | 0.667 | 124.972 |
| **RCA31** | 0.228 | 0.334 | 65.438 |
| **RCA44** | 0.257 | 0.167 | 76.370 |
| **RCA48** | 0.151 | 0.125 | 44.735 |
| **RCA49** | 0.180 | 0.667 | 36.136 |
| **RCA50** | 0.038 | 0.000 | 11.465 |
| **RCA52** | 0.068 | 0.334 | 3.111 |
| **RCA53** | 0.138 | 0.667 | 10.438 |
| **RCA57** | 0.000 | 0.000 | 0.000 |
| **RCA58** | 0.000 | 0.000 | 0.000 |
| **RCA59** | 0.000 | 0.000 | 0.000 |
| **RCA60** | 0.000 | 0.000 | 0.000 |
| **RCA62** | 0.000 | 0.000 | 0.000 |
| **RCA64** | 0.067 | 0.334 | 0.000 |
| **RCA65** | 0.033 | 0.167 | 0.000 |
| **RCA66** | 0.326 | 0.445 | 93.945 |
| **RCA67** | 0.122 | 0.389 | 28.052 |
| **RCA68** | 0.008 | 0.000 | 2.312 |

| | IDI | LDI | CDI |
|---|---|---|---|
| **RCA69** | 0.187 | 0.056 | 55.901 |
| **RCA70** | 0.010 | 0.000 | 2.876 |
| **RCA71** | 0.040 | 0.000 | 11.912 |
| **RCA72** | 0.322 | 1.390 | 49.033 |
| **RCA73** | 0.039 | 0.000 | 11.699 |
| **RCA74** | 0.175 | 0.000 | 52.515 |
| **RCA90** | 0.328 | 0.945 | 80.540 |

**Appendix 3**: Abundance of Ephemeroptera, Plecoptera and Trichoptera in each sampling site.

| | *Alisotrichia* | *Americabaetis* | *Anacroneuria* | *Anchitrichia* | *Apobaetis* | *Askola* | *Asthenopus* | *Atanatolia* | *Atopsyche* | *Aturbina* | *Austrotinodes* | *Baetodes* | *Barypenthus* | *Caenis* | *Callibaetis* | *Camelobaetidius* | *Campsurus* | *Campylocia* | *Chimarra* | *Cloeodes* | *Cryptonympha* | *Cyrnelus* | *Farrodes* | *Grumichella* | *Grypopteryx* | *Guajirolus* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **TMMS0003** | 0 | 23 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 16 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 81 | 0 | 0 | 0 |
| **TMMS0007** | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 23 | 0 | 0 | 0 | 5 | 18 | 0 | 0 | 0 | 1 | 0 | 1 | 3 | 2 | 0 | 0 | 0 |
| **TMMS0009** | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 135 | 0 | 0 | 0 | 0 | 23 | 0 | 0 | 4 | 0 | 0 | 0 |
| **TMMS0027** | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **TMMS0028** | 0 | 43 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 112 | 15 | 0 | 0 | 0 | 0 | 16 | 0 | 0 | 35 | 0 | 1 | 0 |
| **TMMS0033** | 0 | 14 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 24 | 1 | 0 | 0 | 15 | 5 | 0 | 0 | 0 | 0 | 45 | 0 | 0 | 4 | 0 | 0 | 0 |
| **TMMS0040** | 0 | 1 | 0 | 0 | 2 | 8 | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 66 | 57 | 0 | 0 | 4 | 0 | 476 | 1 | 0 | 1 | 0 | 0 | 0 |
| **TMMS0043** | 1 | 1 | 1 | 0 | 2 | 0 | 0 | 0 | 2 | 7 | 0 | 4 | 0 | 19 | 20 | 0 | 0 | 1 | 0 | 22 | 0 | 0 | 2 | 0 | 0 | 0 |
| **TMMS0058** | 0 | 440 | 7 | 0 | 4 | 0 | 0 | 0 | 7 | 1 | 0 | 15 | 0 | 190 | 148 | 0 | 0 | 0 | 26 | 11 | 0 | 0 | 141 | 0 | 0 | 0 |
| **TMMS0072** | 0 | 8 | 11 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 53 | 8 | 0 | 0 | 0 | 2 | 6 | 0 | 0 | 16 | 0 | 0 | 0 |
| **TMMS0082** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| **TMMS0088** | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 55 | 168 | 0 | 0 | 0 | 0 | 43 | 0 | 0 | 2 | 0 | 0 | 0 |
| **TMMS0090** | 0 | 30 | 22 | 0 | 3 | 4 | 0 | 0 | 0 | 32 | 1 | 0 | 0 | 8 | 85 | 0 | 0 | 17 | 0 | 77 | 0 | 0 | 102 | 0 | 0 | 0 |
| **TMMS0091** | 0 | 18 | 38 | 0 | 0 | 0 | 0 | 0 | 1 | 18 | 0 | 6 | 0 | 13 | 173 | 2 | 0 | 0 | 646 | 19 | 0 | 0 | 14 | 0 | 0 | 0 |
| **TMMS0106** | 0 | 1 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 23 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| **TMMS0119** | 0 | 1 | 5 | 0 | 0 | 0 | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 5 | 0 | 0 | 0 |
| **TMMS0126** | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 51 | 0 | 0 | 0 | 4 | 8 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 41 | 0 | 0 | 0 |
| **TMMS0133** | 0 | 5 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| **TMMS0134** | 0 | 1 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 7 | 4 | 0 | 0 | 1 | 0 | 5 | 0 | 0 | 2 | 0 | 0 | 0 |
| **TMMS0137** | 0 | 0 | 0 | 0 | 4 | 0 | 22 | 0 | 0 | 2 | 0 | 0 | 0 | 149 | 24 | 0 | 0 | 0 | 0 | 3 | 0 | 5 | 2 | 0 | 0 | 0 |
| **TMMS0159** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 28 | 1 | 0 | 0 | 1 | 60 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 |
| **TMMS0171** | 1 | 32 | 14 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 49 | 0 | 1 | 41 | 28 | 0 | 2 | 39 | 56 | 0 | 0 | 2 | 0 | 0 | 0 |
| **TMMS0178** | 0 | 105 | 35 | 0 | 2 | 0 | 0 | 0 | 20 | 3 | 0 | 60 | 0 | 220 | 55 | 0 | 0 | 0 | 8 | 74 | 1 | 0 | 34 | 0 | 0 | 0 |
| **TMMS0183** | 0 | 2 | 0 | 0 | 3 | 0 | 0 | 0 | 3 | 3 | 0 | 0 | 0 | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 9 | 0 | 0 | 0 |
| **TMMS0187** | 0 | 38 | 24 | 0 | 2 | 0 | 16 | 0 | 3 | 14 | 2 | 0 | 0 | 18 | 40 | 12 | 0 | 2 | 0 | 44 | 17 | 0 | 61 | 0 | 0 | 0 |
| **TMMS0193** | 0 | 7 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **TMMS0209** | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 5 | 4 | 0 | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **TMMS0214** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **TMMS0220** | 0 | 51 | 22 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 0 | 66 | 16 | 0 | 0 | 0 | 12 | 129 | 0 | 0 | 124 | 0 | 0 | 0 |
| **TMMS0279** | 0 | 31 | 6 | 0 | 11 | 0 | 0 | 0 | 0 | 1 | 0 | 28 | 0 | 0 | 26 | 2 | 0 | 0 | 0 | 5 | 7 | 0 | 4 | 0 | 0 | 0 |
| **TMMS0283** | 0 | 213 | 2 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 5 | 0 | 1 | 1 | 38 | 0 | 0 | 1 | 9 | 6 | 0 | 11 | 0 | 0 | 0 |
| **TMMS0290** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 35 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | *Alisotrichia* | *Americabaetis* | *Anacroneuria* | *Anchitrichia* | *Apobaetis* | *Askola* | *Asthenopus* | *Atanatolia* | *Atopsyche* | *Aturbina* | *Austrotinodes* | *Baetodes* | *Barypenthus* | *Caenis* | *Callibaetis* | *Camelobaetidius* | *Campsurus* | *Campylocia* | *Chimarra* | *Cloeodes* | *Cryptonympha* | *Cyrnelus* | *Farrodes* | *Grumichella* | *Grypopteryx* | *Guajirolus* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **TMMS0296** | 0 | 56 | 13 | 0 | 3 | 0 | 0 | 0 | 0 | 8 | 0 | 20 | 0 | 39 | 50 | 2 | 15 | 2 | 10 | 9 | 0 | 0 | 8 | 0 | 0 | 0 |
| **TMMS0381** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **TMMS0391** | 0 | 4 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 29 | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 |
| **TMMS0437** | 0 | 620 | 2 | 0 | 28 | 0 | 6 | 0 | 0 | 72 | 0 | 0 | 0 | 12 | 39 | 0 | 32 | 0 | 0 | 0 | 0 | 12 | 31 | 0 | 0 | 0 |
| **TMMS1865** | 0 | 3 | 0 | 0 | 2 | 0 | 6 | 0 | 0 | 34 | 0 | 0 | 0 | 23 | 67 | 0 | 0 | 0 | 0 | 12 | 0 | 5 | 10 | 0 | 0 | 0 |
| **TMMS3195** | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| **TMMS3962** | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 3 | 0 | 0 | 0 | 38 | 60 | 0 | 0 | 0 | 0 | 16 | 0 | 0 | 3 | 0 | 0 | 0 |
| **VGMS00002** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **VGMS00004** | 0 | 347 | 65 | 0 | 10 | 0 | 0 | 0 | 0 | 61 | 8 | 10 | 0 | 9 | 0 | 47 | 0 | 0 | 0 | 8 | 0 | 0 | 606 | 0 | 0 | 0 |
| **VGMS00016** | 0 | 30 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 10 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 50 | 0 | 0 | 0 |
| **VGMS00018** | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **VGMS00022** | 6 | 37 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 387 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 25 | 0 | 0 | 0 |
| **VGMS00034** | 0 | 7 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 73 | 2 | 0 | 0 | 0 | 0 | 34 | 0 | 0 | 10 | 0 | 0 | 0 |
| **VGMS00037** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| **VGMS00044** | 0 | 19 | 8 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 32 | 0 | 0 | 0 |
| **VGMS00048** | 0 | 3 | 36 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| **VGMS00080** | 0 | 14 | 4 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 21 | 0 | 0 | 0 |
| **VGMS00109** | 0 | 21 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 4 | 0 | 0 | 0 |
| **VGMS00112** | 1 | 3 | 6 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 32 | 0 | 0 | 0 |
| **VGMS00121** | 0 | 12 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 34 | 0 | 0 | 0 |
| **VGMS00124** | 0 | 24 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 20 | 0 | 1 | 0 | 0 | 4 | 1 | 0 | 0 | 0 | 6 | 12 | 0 | 4 | 0 | 0 | 0 |
| **VGMS00126** | 0 | 38 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| **VGMS00128** | 0 | 121 | 10 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 15 | 0 | 0 | 0 |
| **VGMS00162** | 0 | 11 | 14 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 |
| **VGMS00177** | 0 | 3 | 12 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 37 | 0 | 0 | 0 |
| **VGMS00191** | 0 | 96 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 48 | 0 | 0 | 0 |
| **VGMS00206** | 0 | 72 | 4 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 90 | 0 | 0 | 0 | 0 | 0 | 28 | 0 | 0 | 1 | 0 | 0 | 0 |
| **VGMS00210** | 0 | 79 | 8 | 0 | 2 | 0 | 0 | 0 | 1 | 2 | 0 | 1 | 0 | 21 | 79 | 5 | 0 | 0 | 4 | 126 | 0 | 0 | 5 | 0 | 0 | 0 |
| **VGMS00247** | 0 | 11 | 11 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **VGMS00252** | 0 | 15 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 4 | 0 | 0 | 0 |
| **VGMS00255** | 0 | 47 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **VGMS00277** | 0 | 58 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 43 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 35 | 0 | 0 | 0 |
| **VGMS00306** | 0 | 59 | 28 | 0 | 3 | 0 | 0 | 2 | 3 | 72 | 0 | 14 | 0 | 31 | 64 | 5 | 0 | 0 | 9 | 88 | 0 | 0 | 10 | 0 | 0 | 0 |

| | *Alisotrichia* | *Americabaetis* | *Anacroneuria* | *Anchitrichia* | *Apobaetis* | *Askola* | *Asthenopus* | *Atanatolia* | *Atopsyche* | *Aturbina* | *Austrotinodes* | *Baetodes* | *Barypenthus* | *Caenis* | *Callibaetis* | *Camelobaetidius* | *Campsurus* | *Campylocia* | *Chimarra* | *Cloeodes* | *Cryptonympha* | *Cyrnelus* | *Farrodes* | *Grumichella* | *Grypopteryx* | *Guajirolus* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **VGMS00320** | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 13 | 0 | 0 | 0 |
| **VGMS00380** | 0 | 14 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 23 | 0 | 0 | 0 |
| **VGMS00387** | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **VGMS00418** | 0 | 20 | 20 | 0 | 2 | 0 | 0 | 6 | 26 | 24 | 0 | 12 | 0 | 7 | 2 | 9 | 0 | 0 | 0 | 5 | 0 | 0 | 147 | 0 | 0 | 0 |
| **VGMS00433** | 0 | 1 | 26 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 |
| **VGMS00444** | 1 | 264 | 26 | 0 | 44 | 0 | 0 | 0 | 0 | 97 | 1 | 510 | 0 | 1 | 0 | 32 | 0 | 0 | 86 | 4 | 32 | 0 | 96 | 0 | 0 | 0 |
| **VGMS00447** | 0 | 26 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| **VGMS00450** | 0 | 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **VGMS00511** | 0 | 24 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 |
| **VGMS00515** | 0 | 43 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 14 | 0 | 0 | 0 | 101 | 0 | 0 | 0 | 0 | 0 | 0 | 36 | 0 | 0 | 0 |
| **VGMS00558** | 0 | 58 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 205 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **VGMS00575** | 0 | 12 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 |
| **SSMS0001** | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 4 | 0 | 0 | 0 | 0 | 0 |
| **SSMS0002** | 0 | 72 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 58 | 3 | 0 | 0 | 12 | 1 | 2 | 0 | 0 | 0 | 18 | 7 | 0 | 17 | 0 | 0 | 0 |
| **SSMS0008** | 0 | 61 | 2 | 0 | 19 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 0 | 32 | 14 | 6 | 0 | 0 | 0 | 25 | 1 | 0 | 2 | 0 | 0 | 0 |
| **SSMS0010** | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 3 | 0 | 0 | 0 |
| **SSMS0014** | 0 | 8 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 6 | 0 | 0 | 0 |
| **SSMS0028** | 0 | 30 | 1 | 0 | 6 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 12 | 0 | 0 | 0 | 0 | 2 | 0 | 2 | 0 | 86 | 0 | 0 | 0 |
| **SSMS0029** | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 2 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 |
| **SSMS0031** | 0 | 10 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 6 | 3 | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 0 | 0 | 0 |
| **SSMS0033** | 0 | 28 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **SSMS0035** | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 1 | 15 | 0 | 0 | 1 | 3 | 1 | 0 | 12 | 0 | 0 | 0 |
| **SSMS0037** | 0 | 14 | 0 | 0 | 39 | 0 | 0 | 0 | 0 | 7 | 2 | 0 | 0 | 16 | 53 | 37 | 0 | 0 | 0 | 8 | 1 | 1 | 0 | 0 | 0 | 0 |
| **SSMS0038** | 0 | 8 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 56 | 0 | 0 | 0 |
| **SSMS0044** | 0 | 21 | 5 | 0 | 12 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 1 | 3 | 5 | 0 | 30 | 0 | 0 | 0 |
| **SSMS0051** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **SSMS0053** | 0 | 27 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 0 | 1 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 |
| **SSMS0057** | 0 | 35 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 4 | 0 | 33 | 0 | 0 | 0 | 0 | 32 | 15 | 0 | 0 | 77 | 0 | 0 | 0 |
| **SSMS0059** | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| **SSMS0073** | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **SSMS0078** | 0 | 214 | 14 | 0 | 19 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 0 | 1 | 0 | 32 | 0 | 0 | 0 | 4 | 5 | 0 | 143 | 0 | 0 | 0 |
| **SSMS0094** | 0 | 25 | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 61 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 6 | 15 | 0 | 28 | 0 | 0 | 0 |
| **SSMS0105** | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 7 | 0 | 0 | 0 |

| | *Alisotrichia* | *Americabaetis* | *Anacroneuria* | *Anchitrichia* | *Apobaetis* | *Askola* | *Asthenopus* | *Atanatolia* | *Atopsyche* | *Aturbina* | *Austrotinodes* | *Baetodes* | *Barypenthus* | *Caenis* | *Callibaetis* | *Camelobaetidius* | *Campsurus* | *Campylocia* | *Chimarra* | *Cloeodes* | *Cryptonympha* | *Cyrnelus* | *Farrodes* | *Grumichella* | *Grypopteryx* | *Guajirolus* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **SSMS0126** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **SSMS0129** | 0 | 17 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 30 | 0 | 0 | 0 |
| **SSMS0133** | 2 | 339 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 9 | 78 | 60 | 0 | 0 | 2 | 63 | 7 | 0 | 40 | 0 | 0 | 0 |
| **SSMS0144** | 0 | 9 | 1 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 7 | 2 | 9 | 0 | 0 | 0 | 1 | 8 | 0 | 5 | 0 | 0 | 0 |
| **SSMS0149** | 0 | 13 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 6 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 31 | 0 | 0 | 0 | 0 | 0 |
| **SSMS0150** | 0 | 10 | 8 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 14 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 7 | 0 | 55 | 0 | 0 | 0 |
| **SSMS0157** | 0 | 1 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 28 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 16 | 0 | 0 | 0 |
| **SSMS0175** | 0 | 44 | 144 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 341 | 0 | 1 | 5 | 8 | 0 | 0 | 182 | 43 | 0 | 0 | 46 | 0 | 0 | 0 |
| **SSMS0191** | 0 | 56 | 13 | 0 | 18 | 0 | 0 | 0 | 0 | 2 | 0 | 4 | 0 | 0 | 0 | 11 | 0 | 0 | 10 | 19 | 1 | 0 | 118 | 0 | 0 | 0 |
| **SSMS0193** | 0 | 50 | 4 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 153 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 159 | 0 | 0 | 5 |
| **SSMS0199** | 0 | 3 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 |
| **SSMS0213** | 0 | 23 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 3 | 8 | 0 | 0 | 0 | 44 | 0 | 0 | 0 | 5 | 8 | 0 | 7 | 0 | 0 | 0 |
| **SSMS0351** | 0 | 41 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 2 | 41 | 0 | 0 | 7 | 1 | 0 | 0 | 107 | 0 | 0 | 0 |
| **SSMS0408** | 0 | 2 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **SSMS0411** | 0 | 368 | 6 | 0 | 3 | 0 | 0 | 0 | 3 | 50 | 0 | 2 | 0 | 10 | 9 | 77 | 0 | 0 | 0 | 41 | 0 | 0 | 14 | 0 | 0 | 1 |
| **SSMS0447** | 0 | 13 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 8 | 0 | 0 | 0 | 2 | 1 | 0 | 22 | 0 | 0 | 0 |
| **SSMS1000** | 0 | 22 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 61 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 34 | 0 | 0 | 0 |
| **SSMS4173** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **SSMS4330** | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 4 | 2 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 8 | 0 | 0 | 0 |
| **RENP0008** | 0 | 15 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 9 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| **RENP0012** | 1 | 92 | 12 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 49 | 1 | 1 | 3 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 36 | 0 | 0 | 0 |
| **RENP0016** | 0 | 20 | 1 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 64 | 1 | 3 | 0 | 1 | 0 | 14 | 0 | 0 | 15 | 0 | 0 | 0 |
| **RENP0028** | 0 | 0 | 8 | 0 | 14 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 |
| **RENP0047** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RENP0052** | 0 | 95 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 20 | 0 | 0 | 0 | 0 | 0 |
| **RENP0054** | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RENP0055** | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| **RENP0075** | 0 | 45 | 36 | 0 | 2 | 0 | 0 | 0 | 8 | 5 | 3 | 18 | 0 | 3 | 3 | 5 | 0 | 3 | 0 | 15 | 2 | 0 | 14 | 0 | 0 | 0 |
| **RENP0092** | 0 | 4 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 33 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| **RENP0095** | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| **RENP0096** | 0 | 5 | 23 | 0 | 14 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 |
| **RENP0097** | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 24 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 16 | 0 | 0 | 0 |
| **RENP0100** | 0 | 60 | 14 | 0 | 0 | 0 | 0 | 0 | 4 | 1 | 0 | 0 | 2 | 97 | 6 | 0 | 0 | 0 | 0 | 1 | 24 | 0 | 17 | 0 | 0 | 0 |

| | *Alisotrichia* | *Americabaetis* | *Anacroneuria* | *Anchitrichia* | *Apobaetis* | *Askola* | *Asthenopus* | *Atanatolia* | *Atopsyche* | *Aturbina* | *Austrotinodes* | *Baetodes* | *Barypenthus* | *Caenis* | *Callibaetis* | *Camelobaetidius* | *Campsurus* | *Campylocia* | *Chimarra* | *Cloeodes* | *Cryptonympha* | *Cyrnelus* | *Farrodes* | *Grumichella* | *Grypopteryx* | *Guajirolus* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RENP0108** | 0 | 22 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 1 | 0 |
| **RENP0110** | 0 | 65 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 48 | 0 | 0 | 0 | 3 | 0 | 0 | 2 | 7 | 0 | 0 | 3 | 0 | 0 | 0 |
| **RENP0112** | 0 | 395 | 20 | 0 | 0 | 4 | 0 | 0 | 0 | 5 | 8 | 0 | 2 | 191 | 6 | 0 | 0 | 2 | 1 | 1 | 0 | 0 | 210 | 0 | 0 | 0 |
| **RENP0128** | 0 | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RENP0132** | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 4 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 34 | 0 | 1 | 0 |
| **RENP0139** | 0 | 12 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 |
| **RENP0144** | 0 | 23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 56 | 0 | 16 | 1 | 40 | 5 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 8 | 0 | 0 | 0 |
| **RENP0187** | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| **RENP0192** | 0 | 26 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RENP0203** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 12 | 1 | 2 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 |
| **RENP0228** | 1 | 11 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 9 | 0 |
| **RENP0240** | 0 | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RENP0251** | 0 | 26 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 3 | 1 | 0 | 0 | 0 | 1 | 0 | 7 | 0 |
| **RENP0287** | 0 | 9 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 368 | 155 | 0 | 0 | 0 | 2 | 5 | 0 | 0 | 75 | 0 | 0 | 0 |
| **RENP0368** | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| **RENP0375** | 0 | 34 | 11 | 1 | 7 | 1 | 0 | 0 | 5 | 0 | 1 | 8 | 0 | 5 | 42 | 0 | 0 | 0 | 0 | 8 | 1 | 0 | 1 | 0 | 0 | 0 |
| **RENP0443** | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 |
| **RENP0511** | 0 | 125 | 16 | 0 | 2 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 7 | 0 | 0 | 0 |
| **RENP1524** | 0 | 1 | 107 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 29 | 0 | 4 | 0 | 0 | 0 |
| **RENP2991** | 0 | 150 | 18 | 0 | 0 | 0 | 1 | 0 | 24 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 14 | 0 | 62 | 0 | 0 | 0 |
| **RENP5612** | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RENP7308** | 0 | 14 | 12 | 0 | 0 | 11 | 0 | 0 | 0 | 2 | 0 | 0 | 4 | 7 | 0 | 0 | 0 | 14 | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 0 |
| **RENP9611** | 0 | 5 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| **RENP9757** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RENP12892** | 0 | 145 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RENP15048** | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RCA02** | 0 | 554 | 0 | 0 | 0 | 0 | 0 | 0 | 21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 26 | 0 | 21 | 31 | 0 | 0 |
| **RCA08** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 22 | 13 | 0 | 0 | 0 | 0 | 3 | 1 | 0 | 1 | 0 | 0 | 0 |
| **RCA22** | 0 | 20 | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 0 | 1 | 0 | 0 | 24 | 0 | 0 | 0 | 4 | 0 | 9 | 50 | 0 | 16 | 1 | 0 | 0 |
| **RCA23** | 1 | 51 | 7 | 0 | 0 | 19 | 0 | 0 | 5 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 8 | 0 | 17 | 2 | 1 | 0 |
| **RCA30** | 2 | 40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 7 | 4 | 2 | 0 | 1 | 0 | 6 | 0 | 23 | 6 | 0 | 3 | 31 | 1 | 0 |
| **RCA31** | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RCA44** | 0 | 8 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 0 |

| | *Alisotrichia* | *Americabaetis* | *Anacroneuria* | *Anchitrichia* | *Apobaetis* | *Askola* | *Asthenopus* | *Atanatolia* | *Atopsyche* | *Aturbina* | *Austrotinodes* | *Baetodes* | *Barypenthus* | *Caenis* | *Callibaetis* | *Camelobaetidius* | *Campsurus* | *Campylocia* | *Chimarra* | *Cloeodes* | *Cryptonympha* | *Cyrnelus* | *Farrodes* | *Grumichella* | *Grypopteryx* | *Guajirolus* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RCA48** | 0 | 5 | 59 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 2 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 0 | 0 | 0 |
| **RCA49** | 1 | 1 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 7 | 0 | 4 | 38 | 0 | 0 | 0 | 6 | 0 | 6 | 0 | 0 | 10 | 0 | 0 | 0 |
| **RCA50** | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 5 | 0 | 0 | 0 | 2 | 0 | 5 | 1 | 0 | 0 | 0 | 0 | 0 |
| **RCA52** | 0 | 0 | 22 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 12 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 |
| **RCA53** | 1 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RCA57** | 0 | 3 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 17 | 2 | 0 | 0 | 14 | 0 | 65 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RCA58** | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 23 | 0 | 0 | 7 | 0 | 5 | 0 | 0 | 0 |
| **RCA59** | 1 | 62 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 8 | 96 | 0 | 119 | 40 | 0 | 0 |
| **RCA60** | 1 | 106 | 5 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 32 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 48 | 336 | 0 | 0 |
| **RCA62** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| **RCA64** | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RCA65** | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RCA66** | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 68 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RCA67** | 0 | 4 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 3 | 1 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 17 | 0 | 0 | 0 |
| **RCA68** | 0 | 6 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 0 | 10 | 0 | 0 | 0 | 12 | 0 | 2 | 0 | 0 | 29 | 0 | 0 | 0 |
| **RCA69** | 0 | 3 | 7 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RCA70** | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RCA71** | 0 | 1 | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 5 | 7 | 0 | 0 | 0 | 20 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| **RCA72** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RCA73** | 0 | 1 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RCA74** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| **RCA90** | 0 | 4 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 6 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 0 |

| | *Hagenulopsis* | *Helicopsyche* | *Hermanella* | *Hexagenia* | *Hydroptila* | *Hydrosmilodon* | *Itaura* | *Kempnya* | *Latineosus* | *Leptohyphes* | *Leptohyphodes* | *Leptonema* | *Macronema* | *Macrostemun* | *Marilia* | *Massartella* | *Metrichia* | *Miroculis* | *Mortoniella* | *Nectopsyche* | *Neotrichia* | *Notalina* | *Nyctiophylax* | *Oecetis* | *Oxyetira* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **TMMS0003** | 0 | 0 | 0 | 0 | 0 | 312 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| **TMMS0007** | 0 | 0 | 0 | 4 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 14 | 0 | 0 | 0 | 0 | 0 | 4 | 0 |
| **TMMS0009** | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 |
| **TMMS0027** | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| **TMMS0028** | 0 | 0 | 0 | 0 | 45 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 4 |
| **TMMS0033** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 15 | 0 | 15 | 0 | 0 | 0 | 0 | 0 | 3 | 0 |
| **TMMS0040** | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 16 | 0 | 21 | 0 | 4 | 0 | 0 | 0 | 0 | 0 |
| **TMMS0043** | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 14 | 0 | 6 | 0 | 0 | 0 | 0 | 1 |
| **TMMS0058** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 4 | 0 | 5 | 0 | 0 | 36 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| **TMMS0072** | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| **TMMS0082** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **TMMS0088** | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| **TMMS0090** | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 45 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| **TMMS0091** | 0 | 0 | 10 | 0 | 6 | 20 | 0 | 0 | 0 | 6 | 0 | 5 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 7 | 0 | 0 | 0 | 0 | 11 |
| **TMMS0106** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **TMMS0119** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 6 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 1 | 0 |
| **TMMS0126** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 16 | 0 | 8 | 0 | 0 | 0 | 1 | 0 |
| **TMMS0133** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 4 | 0 |
| **TMMS0134** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **TMMS0137** | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **TMMS0159** | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 2 | 0 | 4 | 0 | 0 | 0 | 1 | 8 |
| **TMMS0171** | 0 | 2 | 16 | 0 | 2 | 12 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| **TMMS0178** | 0 | 0 | 0 | 0 | 26 | 0 | 0 | 0 | 12 | 0 | 0 | 9 | 1 | 0 | 0 | 0 | 3 | 0 | 3 | 18 | 0 | 0 | 0 | 9 | 3 |
| **TMMS0183** | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 4 | 0 | 0 | 0 | 4 | 2 |
| **TMMS0187** | 2 | 4 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 7 | 1 | 0 | 56 | 1 | 1 | 2 | 0 | 0 | 3 | 6 |
| **TMMS0193** | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| **TMMS0209** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 |
| **TMMS0214** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **TMMS0220** | 30 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 8 | 0 | 3 | 0 | 12 | 0 | 0 | 0 | 0 | 0 |
| **TMMS0279** | 0 | 0 | 0 | 2 | 9 | 1 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| **TMMS0283** | 2 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 26 | 0 | 0 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| **TMMS0290** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **TMMS0296** | 0 | 4 | 0 | 0 | 24 | 0 | 0 | 0 | 0 | 13 | 0 | 2 | 3 | 0 | 3 | 0 | 50 | 23 | 2 | 0 | 0 | 0 | 0 | 4 | 2 |

| | *Hagenulopsis* | *Helicopsyche* | *Hermanella* | *Hexagenia* | *Hydroptila* | *Hydrosmilodon* | *Itaura* | *Kempnya* | *Latineosus* | *Leptohyphes* | *Leptohyphodes* | *Leptonema* | *Macronema* | *Macrostemun* | *Marilia* | *Massartella* | *Metrichia* | *Miroculis* | *Mortoniella* | *Nectopsyche* | *Neotrichia* | *Notalina* | *Nyctiophylax* | *Oecetis* | *Oxyetira* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **TMMS0381** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **TMMS0391** | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| **TMMS0437** | 0 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 30 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| **TMMS1865** | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 0 | 7 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 3 |
| **TMMS3195** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **TMMS3962** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 5 | 1 |
| **VGMS00002** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **VGMS00004** | 92 | 0 | 0 | 0 | 77 | 0 | 2 | 0 | 0 | 147 | 0 | 1 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 4 | 0 | 0 | 0 | 1 | 0 |
| **VGMS00016** | 3 | 17 | 0 | 0 | 0 | 36 | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 1 | 0 |
| **VGMS00018** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **VGMS00022** | 2 | 0 | 0 | 0 | 0 | 0 | 9 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| **VGMS00034** | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 1 | 3 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| **VGMS00037** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **VGMS00044** | 8 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 17 | 0 | 0 | 51 | 0 | 1 | 0 | 0 | 0 | 2 | 0 |
| **VGMS00048** | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 |
| **VGMS00080** | 2 | 1 | 0 | 0 | 0 | 4 | 2 | 0 | 0 | 5 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| **VGMS00109** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **VGMS00112** | 3 | 1 | 4 | 0 | 0 | 5 | 0 | 0 | 0 | 20 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **VGMS00121** | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| **VGMS00124** | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 6 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| **VGMS00126** | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 |
| **VGMS00128** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **VGMS00162** | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 16 | 0 | 1 | 1 | 0 | 3 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| **VGMS00177** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 3 | 0 |
| **VGMS00191** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **VGMS00206** | 8 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 10 | 0 | 4 | 0 | 0 | 35 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| **VGMS00210** | 3 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 12 | 0 | 0 | 0 | 0 | 6 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| **VGMS00247** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **VGMS00252** | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| **VGMS00255** | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **VGMS00277** | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| **VGMS00306** | 6 | 0 | 0 | 0 | 0 | 2 | 121 | 0 | 0 | 34 | 0 | 2 | 0 | 0 | 2 | 0 | 0 | 2 | 0 | 4 | 0 | 0 | 0 | 0 | 1 |
| **VGMS00320** | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | *Hagenulopsis* | *Helicopsyche* | *Hermanella* | *Hexagenia* | *Hydroptila* | *Hydrosmilodon* | *Itaura* | *Kempnya* | *Latineosus* | *Leptohyphes* | *Leptohyphodes* | *Leptonema* | *Macronema* | *Macrostemun* | *Marilia* | *Massartella* | *Metrichia* | *Miroculis* | *Mortoniella* | *Nectopsyche* | *Neotrichia* | *Notalina* | *Nyctiophylax* | *Oecetis* | *Oxyetira* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **VGMS00380** | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 32 | 0 | 1 | 0 | 0 | 0 | 3 | 0 |
| **VGMS00387** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **VGMS00418** | 23 | 0 | 0 | 0 | 0 | 0 | 42 | 0 | 0 | 38 | 0 | 6 | 0 | 0 | 5 | 0 | 0 | 80 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| **VGMS00433** | 0 | 14 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| **VGMS00444** | 13 | 3 | 0 | 0 | 0 | 10 | 13 | 0 | 0 | 380 | 0 | 17 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 13 | 1 | 0 | 0 | 1 | 0 |
| **VGMS00447** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **VGMS00450** | 0 | 0 | 0 | 0 | 0 | 0 | 36 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **VGMS00511** | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **VGMS00515** | 8 | 0 | 0 | 0 | 0 | 4 | 21 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| **VGMS00558** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 36 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **VGMS00575** | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **SSMS0001** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| **SSMS0002** | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 6 | 0 | 1 | 0 | 0 | 151 | 0 | 35 | 0 | 0 | 2 | 1 | 0 |
| **SSMS0008** | 13 | 2 | 0 | 0 | 4 | 0 | 2 | 0 | 0 | 2 | 0 | 0 | 33 | 0 | 11 | 0 | 0 | 15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **SSMS0010** | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **SSMS0014** | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| **SSMS0028** | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 20 | 0 | 3 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 1 | 0 |
| **SSMS0029** | 5 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 0 | 0 | 0 | 1 | 0 |
| **SSMS0031** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 131 | 0 | 4 | 0 | 0 | 103 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| **SSMS0033** | 0 | 0 | 0 | 0 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **SSMS0035** | 0 | 0 | 5 | 0 | 0 | 9 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| **SSMS0037** | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 3 | 0 | 1 | 0 | 0 | 13 | 0 | 3 | 0 | 0 | 0 | 3 | 0 |
| **SSMS0038** | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **SSMS0044** | 46 | 6 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 7 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 8 | 0 | 1 | 0 | 0 | 0 | 2 | 0 |
| **SSMS0051** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| **SSMS0053** | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 15 | 0 | 0 | 0 | 0 | 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **SSMS0057** | 0 | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 4 | 0 | 0 | 0 | 0 | 59 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **SSMS0059** | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **SSMS0073** | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| **SSMS0078** | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 11 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 57 | 1 | 0 | 0 | 0 | 0 |
| **SSMS0094** | 4 | 2 | 0 | 0 | 0 | 2 | 12 | 0 | 0 | 2 | 0 | 2 | 1 | 4 | 0 | 0 | 0 | 8 | 0 | 2 | 0 | 0 | 0 | 1 | 0 |
| **SSMS0105** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| **SSMS0126** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | *Hagenulopsis* | *Helicopsyche* | *Hermanella* | *Hexagenia* | *Hydroptila* | *Hydrosmilodon* | *Itaura* | *Kempnya* | *Latineosus* | *Leptohyphes* | *Leptohyphodes* | *Leptonema* | *Macronema* | *Macrostemun* | *Marilia* | *Massartella* | *Metrichia* | *Miroculis* | *Mortoniella* | *Nectopsyche* | *Neotrichia* | *Notalina* | *Nyctiophylax* | *Oecetis* | *Oxyetira* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **SSMS0129** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **SSMS0133** | 0 | 14 | 13 | 0 | 160 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 6 | 0 | 2 | 0 | 0 | 16 | 0 | 5 | 0 | 0 | 3 | 2 | 21 |
| **SSMS0144** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| **SSMS0149** | 0 | 5 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| **SSMS0150** | 0 | 9 | 2 | 0 | 0 | 16 | 0 | 0 | 0 | 12 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| **SSMS0157** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 18 | 0 | 1 | 0 | 0 | 3 | 5 | 0 |
| **SSMS0175** | 6 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 164 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 0 | 3 | 0 | 0 |
| **SSMS0191** | 0 | 23 | 4 | 0 | 3 | 0 | 0 | 0 | 1 | 26 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| **SSMS0193** | 0 | 0 | 5 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| **SSMS0199** | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 34 | 0 | 1 | 0 | 0 | 0 | 2 | 0 |
| **SSMS0213** | 3 | 3 | 3 | 0 | 0 | 19 | 0 | 0 | 0 | 28 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 |
| **SSMS0351** | 0 | 7 | 0 | 0 | 2 | 23 | 0 | 0 | 1 | 26 | 0 | 13 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| **SSMS0408** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **SSMS0411** | 0 | 25 | 62 | 0 | 5 | 1 | 2 | 0 | 10 | 14 | 0 | 0 | 14 | 0 | 3 | 0 | 29 | 9 | 0 | 11 | 0 | 0 | 0 | 2 | 0 |
| **SSMS0447** | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| **SSMS1000** | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 19 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **SSMS4173** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **SSMS4330** | 1 | 24 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 6 | 0 |
| **RENP0008** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RENP0012** | 0 | 0 | 0 | 0 | 6 | 0 | 1 | 0 | 0 | 1 | 0 | 9 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 |
| **RENP0016** | 19 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 0 | 1 | 13 | 0 | 0 | 2 | 0 | 0 | 0 | 6 |
| **RENP0028** | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| **RENP0047** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RENP0052** | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RENP0054** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 3 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 19 | 0 | 0 | 0 | 2 | 0 | 1 | 0 |
| **RENP0055** | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RENP0075** | 59 | 0 | 0 | 0 | 3 | 0 | 8 | 5 | 0 | 0 | 0 | 11 | 2 | 0 | 12 | 0 | 0 | 29 | 0 | 0 | 0 | 7 | 0 | 8 | 1 |
| **RENP0092** | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| **RENP0095** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 11 | 0 | 0 | 12 | 0 | 0 | 0 | 26 | 0 | 5 | 0 |
| **RENP0096** | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RENP0097** | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 18 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RENP0100** | 58 | 0 | 0 | 0 | 0 | 0 | 51 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 6 | 0 | 0 | 17 | 0 | 11 | 0 | 0 | 0 | 0 | 3 |
| **RENP0108** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 27 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |

| | *Hagenulopsis* | *Helicopsyche* | *Hermanella* | *Hexagenia* | *Hydroptila* | *Hydrosmilodon* | *Itaura* | *Kempnya* | *Latineosus* | *Leptohyphes* | *Leptohyphodes* | *Leptonema* | *Macronema* | *Macrostemun* | *Marilia* | *Massartella* | *Metrichia* | *Miroculis* | *Mortoniella* | *Nectopsyche* | *Neotrichia* | *Notalina* | *Nyctiophylax* | *Oecetis* | *Oxyetira* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RENP0110** | 0 | 0 | 0 | 0 | 0 | 0 | 22 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 3 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 |
| **RENP0112** | 24 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 6 | 0 | 0 | 3 | 5 | 0 | 68 | 0 | 0 | 4 | 2 | 0 | 0 | 0 |
| **RENP0128** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RENP0132** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 2 | 0 | 1 | 1 | 0 | 8 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| **RENP0139** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RENP0144** | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 1 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| **RENP0187** | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RENP0192** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RENP0203** | 0 | 0 | 0 | 0 | 3 | 0 | 5 | 0 | 0 | 0 | 0 | 14 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| **RENP0228** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| **RENP0240** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RENP0251** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 7 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RENP0287** | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 1 | 0 | 6 | 14 | 0 | 5 | 0 | 1 | 0 | 0 | 0 | 4 | 0 |
| **RENP0368** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RENP0375** | 11 | 0 | 0 | 0 | 0 | 2 | 17 | 1 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| **RENP0443** | 0 | 0 | 0 | 0 | 0 | 0 | 20 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RENP0511** | 0 | 0 | 0 | 0 | 13 | 0 | 119 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 0 | 1 | 0 | 9 | 0 |
| **RENP1524** | 2 | 0 | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 6 | 1 | 0 | 27 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RENP2991** | 0 | 0 | 0 | 0 | 2 | 0 | 27 | 0 | 0 | 3 | 0 | 1 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| **RENP5612** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| **RENP7308** | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 7 | 2 | 0 | 1 | 1 | 23 | 0 | 26 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| **RENP9611** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 8 | 8 | 1 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| **RENP9757** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RENP12892** | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 128 |
| **RENP15048** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RCA02** | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 2 |
| **RCA08** | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 6 | 0 | 1 | 0 |
| **RCA22** | 8 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 42 | 0 | 8 | 0 | 1 | 0 | 0 | 1 |
| **RCA23** | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 94 | 8 | 0 | 0 | 1 | 1 | 0 | 0 | 1 |
| **RCA30** | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 14 | 23 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| **RCA31** | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RCA44** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 0 | 0 | 0 | 0 | 0 | 0 | 14 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 |
| **RCA48** | 82 | 1 | 0 | 0 | 2 | 0 | 35 | 1 | 0 | 0 | 0 | 4 | 3 | 5 | 173 | 0 | 0 | 0 | 0 | 171 | 9 | 0 | 0 | 0 | 0 |

| | *Hagenulopsis* | *Helicopsyche* | *Hermanella* | *Hexagenia* | *Hydroptila* | *Hydrosmilodon* | *Itaura* | *Kempnya* | *Latineosus* | *Leptohyphes* | *Leptohyphodes* | *Leptonema* | *Macronema* | *Macrostemun* | *Marilia* | *Massartella* | *Metrichia* | *Miroculis* | *Mortoniella* | *Nectopsyche* | *Neotrichia* | *Notalina* | *Nyctiophylax* | *Oecetis* | *Oxyetira* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RCA49** | 8 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 9 | 3 | 7 | 1 | 8 | 17 | 0 | 0 | 0 | 5 | 0 | 0 | 0 |
| **RCA50** | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 42 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 2 | 0 |
| **RCA52** | 31 | 0 | 0 | 0 | 8 | 0 | 5 | 13 | 0 | 0 | 0 | 1 | 0 | 0 | 69 | 0 | 0 | 9 | 0 | 2 | 0 | 2 | 0 | 2 | 0 |
| **RCA53** | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| **RCA57** | 5 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 7 | 0 | 4 | 0 | 0 | 62 | 0 | 0 | 0 | 23 | 0 | 0 | 0 |
| **RCA58** | 2 | 1 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 9 | 0 | 4 | 0 | 42 | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 37 |
| **RCA59** | 0 | 0 | 20 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 0 | 1 | 0 | 0 | 12 | 0 | 0 | 3 | 7 | 0 | 0 | 0 | 17 |
| **RCA60** | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 21 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 21 |
| **RCA62** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 108 | 0 | 0 | 0 | 0 | 0 | 26 | 0 |
| **RCA64** | 6 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| **RCA65** | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RCA66** | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 5 | 0 |
| **RCA67** | 4 | 0 | 0 | 0 | 0 | 0 | 6 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 2 | 9 | 0 | 3 | 0 |
| **RCA68** | 15 | 1 | 0 | 0 | 0 | 0 | 15 | 2 | 0 | 0 | 0 | 1 | 5 | 25 | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| **RCA69** | 7 | 0 | 0 | 0 | 0 | 2 | 6 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 8 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RCA70** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RCA71** | 11 | 4 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 9 | 2 | 0 | 8 | 3 | 0 | 0 | 6 | 0 | 0 | 2 | 0 | 0 | 1 | 0 |
| **RCA72** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RCA73** | 10 | 0 | 1 | 0 | 0 | 0 | 8 | 1 | 0 | 0 | 0 | 1 | 0 | 3 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RCA74** | 1 | 8 | 0 | 0 | 0 | 2 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 18 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 |
| **RCA90** | 1 | 0 | 0 | 0 | 0 | 0 | 32 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | *Paracloeodes* | *Paragrypopteryx* | *Paramaka* | *Phylloicus* | *Polycentropus* | *Polyplectropus* | *Protoptila* | *Rivudiva* | *Simothraulopsis* | *Smicridea* | *Spiritiops* | *Terpides* | *Thraulodes* | *Traverhyphes* | *Tricorythodes* | *Tricorythopsis* | *Triplectides* | *Tupiperla* | *Ulmeritoides* | *Varipes* | *Waltzoyphius* | *Wormaldia* | *Zelusia* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **TMMS0003** | 1 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 133 | 0 | 0 | 0 | 2 | 149 | 0 | 0 | 0 | 0 | 0 | 17 | 0 | 3 |
| **TMMS0007** | 2 | 0 | 0 | 0 | 6 | 1 | 0 | 0 | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 0 | 4 |
| **TMMS0009** | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 12 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| **TMMS0027** | 1 | 0 | 0 | 0 | 3 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 16 | 0 | 0 |
| **TMMS0028** | 27 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 24 | 401 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 |
| **TMMS0033** | 8 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 1 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 16 | 0 | 1 | 0 | 16 |
| **TMMS0040** | 32 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 0 | 0 | 0 | 38 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 8 |
| **TMMS0043** | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 10 | 1 | 1 | 0 | 0 | 34 | 0 | 11 | 0 | 2 |
| **TMMS0058** | 7 | 0 | 0 | 1 | 0 | 3 | 0 | 0 | 0 | 55 | 0 | 0 | 135 | 66 | 0 | 0 | 0 | 0 | 35 | 0 | 2 | 0 | 0 |
| **TMMS0072** | 0 | 0 | 0 | 1 | 0 | 6 | 0 | 0 | 0 | 84 | 0 | 0 | 9 | 27 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| **TMMS0082** | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 11 | 1 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 1 |
| **TMMS0088** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 73 | 3 | 2 | 0 | 0 | 63 | 0 | 0 | 0 | 0 |
| **TMMS0090** | 19 | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 4 |
| **TMMS0091** | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 26 | 0 | 0 | 170 | 85 | 2 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| **TMMS0106** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 |
| **TMMS0119** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 |
| **TMMS0126** | 3 | 0 | 0 | 0 | 24 | 6 | 0 | 0 | 7 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 11 |
| **TMMS0133** | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 7 | 0 | 0 |
| **TMMS0134** | 0 | 0 | 0 | 22 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 2 |
| **TMMS0137** | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 21 | 0 | 0 | 5 | 0 | 22 | 0 | 1 | 0 | 3 |
| **TMMS0159** | 18 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 9 | 154 | 10 | 4 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| **TMMS0171** | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 2 | 47 | 0 | 0 | 69 | 180 | 7 | 3 | 0 | 0 | 4 | 0 | 0 | 0 | 0 |
| **TMMS0178** | 0 | 0 | 0 | 0 | 2 | 17 | 2 | 0 | 0 | 6 | 0 | 0 | 52 | 343 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 1 | 0 |
| **TMMS0183** | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 75 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| **TMMS0187** | 17 | 0 | 0 | 18 | 0 | 1 | 0 | 0 | 2 | 4 | 0 | 0 | 5 | 15 | 0 | 11 | 1 | 0 | 18 | 0 | 7 | 0 | 0 |
| **TMMS0193** | 0 | 0 | 0 | 0 | 4 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 24 | 0 | 0 | 1 | 0 | 0 | 0 | 13 | 0 | 0 |
| **TMMS0209** | 0 | 0 | 0 | 0 | 36 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 0 | 0 |
| **TMMS0214** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **TMMS0220** | 0 | 0 | 0 | 0 | 1 | 7 | 0 | 0 | 0 | 55 | 0 | 0 | 92 | 869 | 0 | 0 | 2 | 0 | 4 | 0 | 0 | 0 | 0 |
| **TMMS0279** | 1 | 0 | 0 | 0 | 7 | 2 | 0 | 0 | 0 | 13 | 0 | 0 | 1 | 59 | 0 | 21 | 1 | 0 | 7 | 0 | 0 | 0 | 0 |
| **TMMS0283** | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 8 | 8 | 0 | 4 | 12 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **TMMS0290** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **TMMS0296** | 6 | 0 | 0 | 1 | 0 | 10 | 0 | 0 | 7 | 38 | 0 | 0 | 50 | 171 | 6 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 |

| | *Paracloeodes* | *Paragrypopteryx* | *Paramaka* | *Phylloicus* | *Polycentropus* | *Polyplectropus* | *Protoptila* | *Rivudiva* | *Simothraulopsis* | *Smicridea* | *Spiritiops* | *Terpides* | *Thraulodes* | *Traverhyphes* | *Tricorythodes* | *Tricorythopsis* | *Triplectides* | *Tupiperla* | *Ulmeritoides* | *Varipes* | *Waltzoyphius* | *Wormaldia* | *Zelusia* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **TMMS0381** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| **TMMS0391** | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 14 | 0 | 0 | 0 | 2 | 4 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| **TMMS0437** | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 2 | 37 | 0 | 0 | 0 | 14 | 14 | 0 | 0 | 0 | 4 | 0 | 198 | 0 | 4 |
| **TMMS1865** | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 1 | 0 | 0 | 2 | 35 | 1 | 0 | 6 | 0 | 0 | 0 | 35 | 0 | 5 |
| **TMMS3195** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **TMMS3962** | 0 | 0 | 0 | 0 | 11 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 7 | 0 | 4 | 0 | 2 |
| **VGMS00002** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 22 | 0 | 0 |
| **VGMS00004** | 0 | 0 | 0 | 6 | 0 | 0 | 5 | 0 | 0 | 51 | 0 | 14 | 84 | 15 | 4 | 0 | 1 | 0 | 47 | 0 | 3 | 0 | 142 |
| **VGMS00016** | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 6 | 0 | 1 | 2 | 17 | 5 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 8 |
| **VGMS00018** | 0 | 0 | 0 | 4 | 7 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 16 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 0 |
| **VGMS00022** | 0 | 0 | 0 | 123 | 0 | 0 | 0 | 0 | 0 | 15 | 0 | 1 | 2 | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 0 | 12 |
| **VGMS00034** | 2 | 0 | 0 | 34 | 0 | 0 | 0 | 0 | 0 | 22 | 0 | 0 | 0 | 48 | 4 | 0 | 0 | 0 | 3 | 0 | 2 | 0 | 1 |
| **VGMS00037** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **VGMS00044** | 22 | 0 | 0 | 12 | 0 | 0 | 1 | 3 | 0 | 9 | 0 | 27 | 12 | 7 | 10 | 0 | 0 | 0 | 83 | 0 | 16 | 0 | 27 |
| **VGMS00048** | 0 | 0 | 0 | 4 | 0 | 1 | 0 | 0 | 0 | 107 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| **VGMS00080** | 2 | 0 | 0 | 4 | 0 | 0 | 1 | 0 | 0 | 7 | 0 | 0 | 0 | 4 | 8 | 2 | 1 | 0 | 0 | 0 | 1 | 0 | 17 |
| **VGMS00109** | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 9 | 20 | 0 | 0 | 0 | 2 | 0 | 10 | 0 | 56 |
| **VGMS00112** | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 16 | 0 | 1 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 12 |
| **VGMS00121** | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 65 | 0 | 3 | 0 | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 13 |
| **VGMS00124** | 56 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 0 | 2 | 8 | 7 | 0 | 0 | 0 | 0 | 13 | 0 | 10 | 0 | 4 |
| **VGMS00126** | 0 | 0 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 114 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **VGMS00128** | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 21 | 0 | 49 |
| **VGMS00162** | 11 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 1 | 1 | 2 | 12 | 0 | 0 | 0 | 3 | 0 | 9 | 0 | 53 |
| **VGMS00177** | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 105 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| **VGMS00191** | 0 | 0 | 0 | 0 | 1 | 0 | 31 | 0 | 0 | 280 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| **VGMS00206** | 1 | 0 | 0 | 93 | 0 | 0 | 0 | 0 | 0 | 90 | 0 | 1 | 31 | 90 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| **VGMS00210** | 23 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 7 | 0 | 1 | 112 | 35 | 7 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 1 |
| **VGMS00247** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 21 | 1 | 0 | 1 | 0 | 0 | 0 | 3 | 0 | 10 |
| **VGMS00252** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 6 | 3 | 1 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| **VGMS00255** | 2 | 0 | 0 | 0 | 2 | 0 | 5 | 0 | 0 | 2 | 0 | 0 | 0 | 13 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| **VGMS00277** | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 3 | 12 | 11 | 2 | 0 | 0 | 5 | 0 | 7 | 0 | 28 |
| **VGMS00306** | 14 | 0 | 0 | 3 | 0 | 0 | 8 | 0 | 0 | 18 | 0 | 12 | 583 | 26 | 49 | 2 | 0 | 0 | 19 | 0 | 0 | 0 | 6 |
| **VGMS00320** | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 7 | 0 | 0 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

| | *Paracloeodes* | *Paragrypopteryx* | *Paramaka* | *Phylloicus* | *Polycentropus* | *Polyplectropus* | *Protoptila* | *Rivudiva* | *Simothraulopsis* | *Smicridea* | *Spiritiops* | *Terpides* | *Thraulodes* | *Traverhyphes* | *Tricorythodes* | *Tricorythopsis* | *Triplectides* | *Tupiperla* | *Ulmeritoides* | *Varipes* | *Waltzoyphius* | *Wormaldia* | *Zelusia* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **VGMS00380** | 35 | 0 | 0 | 6 | 4 | 0 | 2 | 0 | 0 | 2 | 0 | 3 | 1 | 38 | 12 | 1 | 0 | 0 | 43 | 0 | 9 | 0 | 8 |
| **VGMS00387** | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| **VGMS00418** | 7 | 0 | 0 | 5 | 2 | 0 | 0 | 0 | 0 | 19 | 0 | 6 | 58 | 44 | 78 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 6 |
| **VGMS00433** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 16 | 0 | 0 | 0 | 0 | 4 | 5 | 0 | 0 | 0 | 0 | 1 | 0 | 38 |
| **VGMS00444** | 11 | 0 | 0 | 0 | 0 | 0 | 32 | 0 | 0 | 97 | 0 | 10 | 236 | 115 | 3 | 5 | 0 | 0 | 2 | 0 | 4 | 0 | 3 |
| **VGMS00447** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 30 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| **VGMS00450** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **VGMS00511** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **VGMS00515** | 0 | 0 | 0 | 5 | 0 | 0 | 8 | 1 | 0 | 21 | 0 | 0 | 11 | 1 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **VGMS00558** | 0 | 0 | 0 | 0 | 0 | 0 | 98 | 0 | 0 | 210 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 |
| **VGMS00575** | 2 | 0 | 0 | 14 | 0 | 0 | 5 | 0 | 0 | 5 | 0 | 1 | 2 | 11 | 2 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 9 |
| **SSMS0001** | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 6 |
| **SSMS0002** | 51 | 0 | 0 | 52 | 0 | 4 | 0 | 2 | 0 | 1 | 0 | 41 | 7 | 126 | 0 | 3 | 0 | 0 | 11 | 0 | 19 | 0 | 111 |
| **SSMS0008** | 0 | 0 | 0 | 3 | 0 | 2 | 2 | 0 | 0 | 3 | 0 | 11 | 7 | 35 | 1 | 0 | 0 | 0 | 5 | 0 | 2 | 0 | 0 |
| **SSMS0010** | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 |
| **SSMS0014** | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| **SSMS0028** | 0 | 0 | 0 | 3 | 0 | 0 | 1 | 0 | 0 | 43 | 0 | 0 | 1 | 180 | 1 | 1 | 0 | 0 | 1 | 0 | 2 | 0 | 31 |
| **SSMS0029** | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 26 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **SSMS0031** | 4 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 18 | 0 | 141 | 0 | 68 |
| **SSMS0033** | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 686 | 0 | 0 | 0 | 11 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **SSMS0035** | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 6 | 0 | 3 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **SSMS0037** | 48 | 0 | 0 | 10 | 0 | 0 | 8 | 15 | 0 | 0 | 0 | 1 | 18 | 17 | 5 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 2 |
| **SSMS0038** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 |
| **SSMS0044** | 12 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 10 | 0 | 49 | 79 | 5 | 0 | 0 | 19 | 0 | 4 | 0 | 25 |
| **SSMS0051** | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| **SSMS0053** | 3 | 0 | 0 | 7 | 0 | 4 | 0 | 18 | 0 | 6 | 0 | 6 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 |
| **SSMS0057** | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 84 | 0 | 0 | 1 | 3 | 0 | 0 | 0 | 0 | 21 | 0 | 0 | 0 | 0 |
| **SSMS0059** | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| **SSMS0073** | 0 | 0 | 0 | 0 | 0 | 0 | 22 | 0 | 0 | 124 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **SSMS0078** | 123 | 0 | 0 | 2 | 0 | 0 | 1 | 2 | 0 | 93 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **SSMS0094** | 0 | 0 | 0 | 3 | 0 | 23 | 0 | 5 | 0 | 35 | 0 | 0 | 118 | 6 | 42 | 3 | 0 | 0 | 7 | 0 | 0 | 0 | 45 |
| **SSMS0105** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| **SSMS0126** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | *Paracloeodes* | *Paragrypopteryx* | *Paramaka* | *Phylloicus* | *Polycentropus* | *Polyplectropus* | *Protoptila* | *Rivudiva* | *Simothraulopsis* | *Smicridea* | *Spiritiops* | *Terpides* | *Thraulodes* | *Traverhyphes* | *Tricorythodes* | *Tricorythopsis* | *Triplectides* | *Tupiperla* | *Ulmeritoides* | *Varipes* | *Waltzoyphius* | *Wormaldia* | *Zelusia* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **SSMS0129** | 5 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 5 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| **SSMS0133** | 59 | 0 | 0 | 0 | 0 | 6 | 1 | 6 | 0 | 35 | 0 | 1 | 0 | 17 | 33 | 6 | 0 | 0 | 1 | 0 | 0 | 0 | 2 |
| **SSMS0144** | 0 | 0 | 0 | 2 | 1 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 16 | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 5 |
| **SSMS0149** | 4 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **SSMS0150** | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 33 | 8 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| **SSMS0157** | 0 | 0 | 0 | 66 | 7 | 1 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 9 | 0 | 0 | 3 | 0 | 6 | 0 | 2 | 0 | 13 |
| **SSMS0175** | 7 | 0 | 1 | 8 | 1 | 6 | 6 | 0 | 0 | 133 | 0 | 2 | 300 | 17 | 3 | 0 | 0 | 0 | 3 | 0 | 6 | 38 | 27 |
| **SSMS0191** | 39 | 0 | 0 | 0 | 0 | 0 | 1 | 14 | 0 | 7 | 0 | 0 | 12 | 7 | 42 | 2 | 0 | 0 | 5 | 0 | 6 | 1 | 62 |
| **SSMS0193** | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 57 | 0 | 0 | 0 | 87 | 48 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 2 |
| **SSMS0199** | 0 | 0 | 0 | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 2 | 0 | 0 | 5 | 0 | 1 | 0 | 11 |
| **SSMS0213** | 1 | 0 | 0 | 2 | 0 | 1 | 6 | 0 | 0 | 15 | 0 | 0 | 20 | 3 | 3 | 5 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| **SSMS0351** | 21 | 0 | 1 | 3 | 0 | 1 | 4 | 0 | 0 | 30 | 0 | 10 | 141 | 47 | 5 | 4 | 0 | 0 | 2 | 0 | 0 | 1 | 1 |
| **SSMS0408** | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| **SSMS0411** | 57 | 0 | 0 | 2 | 0 | 1 | 4 | 7 | 0 | 24 | 0 | 0 | 69 | 78 | 9 | 0 | 0 | 0 | 12 | 0 | 2 | 0 | 6 |
| **SSMS0447** | 8 | 0 | 0 | 1 | 0 | 0 | 2 | 6 | 0 | 2 | 0 | 0 | 2 | 3 | 14 | 1 | 0 | 0 | 2 | 0 | 1 | 0 | 22 |
| **SSMS1000** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 20 | 0 | 1 | 35 | 23 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 4 |
| **SSMS4173** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 439 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **SSMS4330** | 1 | 0 | 0 | 3 | 0 | 0 | 1 | 0 | 0 | 18 | 0 | 0 | 0 | 52 | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 1 |
| **RENP0008** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 41 | 0 | 0 |
| **RENP0012** | 6 | 3 | 0 | 2 | 0 | 4 | 0 | 0 | 0 | 31 | 0 | 0 | 2 | 389 | 0 | 73 | 0 | 5 | 0 | 0 | 0 | 0 | 0 |
| **RENP0016** | 9 | 0 | 0 | 1 | 0 | 8 | 0 | 0 | 1 | 0 | 0 | 0 | 153 | 22 | 0 | 88 | 0 | 0 | 2 | 0 | 2 | 0 | 0 |
| **RENP0028** | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 5 | 0 | 0 | 17 | 14 | 0 | 11 | 1 | 1 | 2 | 0 | 1 | 0 | 2 |
| **RENP0047** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RENP0052** | 0 | 59 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 38 | 0 | 0 | 1 | 9 | 0 | 0 | 0 | 0 | 0 |
| **RENP0054** | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 4 | 0 | 0 | 1 | 0 | 13 |
| **RENP0055** | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 19 | 0 | 1 | 0 | 0 | 4 | 0 | 1 |
| **RENP0075** | 75 | 0 | 0 | 2 | 1 | 21 | 0 | 0 | 6 | 2 | 0 | 27 | 67 | 66 | 11 | 74 | 0 | 0 | 59 | 0 | 1 | 0 | 0 |
| **RENP0092** | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 42 | 0 | 0 | 0 | 4 | 0 | 0 | 2 | 5 | 6 | 0 | 0 | 0 | 0 |
| **RENP0095** | 0 | 1 | 0 | 29 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 17 | 1 | 54 | 18 | 0 | 0 | 0 | 0 | 1 |
| **RENP0096** | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 20 | 0 | 0 | 103 | 41 | 2 | 24 | 5 | 0 | 1 | 0 | 0 | 0 | 0 |
| **RENP0097** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 0 | 0 | 8 | 62 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 |
| **RENP0100** | 20 | 0 | 0 | 2 | 1 | 3 | 0 | 0 | 0 | 7 | 0 | 0 | 211 | 88 | 0 | 183 | 3 | 4 | 0 | 0 | 4 | 0 | 0 |
| **RENP0108** | 2 | 35 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 37 | 0 | 0 | 1 | 2 | 5 | 6 | 2 | 101 | 0 | 0 | 0 | 0 | 4 |

| | *Paracloeodes* | *Paragrypopteryx* | *Paramaka* | *Phylloicus* | *Polycentropus* | *Polyplectropus* | *Protoptila* | *Rivudiva* | *Simothraulopsis* | *Smicridea* | *Spiritiops* | *Terpides* | *Thraulodes* | *Traverhyphes* | *Tricorythodes* | *Tricorythopsis* | *Triplectides* | *Tupiperla* | *Ulmeritoides* | *Varipes* | *Waltzoyphius* | *Wormaldia* | *Zelusia* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RENP0110** | 9 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 22 | 0 | 0 | 0 | 40 | 6 | 9 | 0 | 6 | 0 | 0 | 0 | 0 | 2 |
| **RENP0112** | 23 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 23 | 0 | 3 | 61 | 146 | 0 | 4 | 13 | 0 | 20 | 0 | 2 | 0 | 45 |
| **RENP0128** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 92 | 0 | 1 |
| **RENP0132** | 3 | 5 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 16 | 81 | 2 | 57 | 10 | 106 | 0 | 0 | 6 | 0 | 6 |
| **RENP0139** | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 5 | 0 | 2 | 0 | 0 | 3 | 0 | 5 | 0 | 8 |
| **RENP0144** | 91 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 34 | 24 | 0 | 0 | 0 | 3 | 18 | 0 | 0 | 0 | 6 |
| **RENP0187** | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 21 | 0 | 35 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| **RENP0192** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RENP0203** | 1 | 0 | 0 | 0 | 1 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 637 | 0 | 219 | 1 | 7 | 0 | 0 | 0 | 0 | 0 |
| **RENP0228** | 3 | 2 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 25 | 1 | 0 | 3 | 2 | 0 | 0 | 2 | 0 | 0 |
| **RENP0240** | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| **RENP0251** | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 122 | 0 | 28 | 0 | 15 | 0 | 0 | 1 | 0 | 1 |
| **RENP0287** | 34 | 7 | 0 | 17 | 0 | 0 | 0 | 0 | 0 | 56 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 113 | 13 | 0 | 1 | 0 | 25 |
| **RENP0368** | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 68 | 1 | 9 | 4 | 1 | 1 | 0 | 4 | 0 | 1 |
| **RENP0375** | 17 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 303 | 23 | 0 | 136 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| **RENP0443** | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 58 | 0 | 42 | 0 | 0 | 2 | 0 | 0 | 0 | 3 |
| **RENP0511** | 12 | 0 | 0 | 1 | 0 | 0 | 64 | 1 | 0 | 14 | 0 | 0 | 3 | 91 | 1 | 88 | 1 | 0 | 9 | 4 | 1 | 0 | 1 |
| **RENP1524** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 34 | 0 | 1 |
| **RENP2991** | 26 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 30 | 68 | 0 | 7 | 0 | 0 | 4 | 0 | 14 | 0 | 1 |
| **RENP5612** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RENP7308** | 0 | 3 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 21 | 0 | 10 | 42 | 25 | 59 | 0 | 0 | 0 | 13 |
| **RENP9611** | 0 | 4 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 27 | 0 | 7 | 17 | 11 | 0 | 0 | 0 | 0 | 9 |
| **RENP9757** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RENP12892** | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 49 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 4 | 0 | 0 |
| **RENP15048** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RCA02** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| **RCA08** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 169 | 0 | 0 | 0 | 0 |
| **RCA22** | 38 | 0 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 11 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RCA23** | 8 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 98 | 0 | 0 | 0 | 0 | 0 | 16 | 37 | 0 | 0 | 0 | 0 | 0 | 2 |
| **RCA30** | 8 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 3 | 21 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| **RCA31** | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RCA44** | 0 | 0 | 0 | 4 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RCA48** | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 171 | 0 | 0 | 109 | 137 | 0 | 39 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | *Paracloeodes* | *Paragrypopteryx* | *Paramaka* | *Phylloicus* | *Polycentropus* | *Polyplectropus* | *Protoptila* | *Rivudiva* | *Simothraulopsis* | *Smicridea* | *Spiritiops* | *Terpides* | *Thraulodes* | *Traverhyphes* | *Tricorythodes* | *Tricorythopsis* | *Triplectides* | *Tupiperla* | *Ulmeritoides* | *Varipes* | *Waltzoyphius* | *Wormaldia* | *Zelusia* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RCA49** | 0 | 0 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 77 | 0 | 0 | 0 | 85 | 0 | 34 | 1 | 10 | 11 | 0 | 7 | 0 | 2 |
| **RCA50** | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 18 | 3 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RCA52** | 2 | 0 | 0 | 0 | 2 | 17 | 0 | 0 | 0 | 37 | 0 | 0 | 159 | 22 | 0 | 108 | 2 | 0 | 0 | 0 | 0 | 3 | 0 |
| **RCA53** | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 11 | 0 | 0 | 9 | 2 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RCA57** | 38 | 0 | 0 | 5 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RCA58** | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RCA59** | 13 | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 71 | 0 | 0 | 0 | 1 | 0 | 61 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| **RCA60** | 0 | 7 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 19 | 0 | 0 | 0 | 1 | 0 | 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RCA62** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RCA64** | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 1 | 0 |
| **RCA65** | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RCA66** | 1 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 12 | 0 | 0 | 41 | 0 | 3 | 0 | 8 | 0 | 0 | 0 | 0 |
| **RCA67** | 1 | 0 | 0 | 4 | 0 | 2 | 0 | 0 | 0 | 8 | 0 | 13 | 0 | 40 | 0 | 4 | 6 | 1 | 14 | 0 | 2 | 0 | 0 |
| **RCA68** | 0 | 0 | 0 | 4 | 1 | 3 | 0 | 0 | 0 | 26 | 0 | 0 | 13 | 73 | 0 | 22 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| **RCA69** | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 16 | 0 | 1 | 6 | 16 | 0 | 8 | 2 | 2 | 0 | 0 | 1 | 0 | 0 |
| **RCA70** | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RCA71** | 0 | 2 | 0 | 8 | 0 | 1 | 0 | 0 | 0 | 24 | 0 | 0 | 0 | 29 | 0 | 18 | 7 | 1 | 51 | 0 | 0 | 0 | 3 |
| **RCA72** | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 66 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RCA73** | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 20 | 0 | 0 | 37 | 14 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **RCA74** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 0 | 0 | 26 | 5 | 0 | 12 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| **RCA90** | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 8 | 5 | 0 | 22 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

**Appendix 4**: Abundance, count and average body size of each taxon measured in each sampling site.

| Site | Taxon | Abundance | Count | Average size (cm) |
|---|---|---|---|---|
| **TMMS0003** | *Farrodes* | 81 | 7 | 3.81 |
| **TMMS0003** | *Hydrosmilodon* | 312 | 69 | 3.84 |
| **TMMS0003** | *Tricorythodes* | 149 | 32 | 3.19 |
| **TMMS0007** | *Hexagenia* | 4 | 4 | 5.27 |
| **TMMS0009** | *Cloeodes* | 23 | 22 | 2.91 |
| **TMMS0028** | *Caenis* | 112 | 10 | 4.65 |
| **TMMS0028** | *Farrodes* | 35 | 19 | 2.57 |
| **TMMS0028** | *Massartella* | 3 | 3 | 7.66 |
| **TMMS0028** | *Ulmeritoides* | 7 | 3 | 5.60 |
| **TMMS0040** | *Caenis* | 66 | 23 | 2.48 |
| **TMMS0040** | *Campylocia* | 4 | 4 | 16.44 |
| **TMMS0040** | *Cloeodes* | 476 | 23 | 2.80 |
| **TMMS0040** | *Massartella* | 16 | 16 | 9.77 |
| **TMMS0040** | *Miroculis* | 21 | 10 | 3.19 |
| **TMMS0040** | *Ulmeritoides* | 5 | 3 | 8.33 |
| **TMMS0043** | *Helicopsyche* | 9 | 3 | 4.23 |
| **TMMS0043** | *Miroculis* | 14 | 7 | 2.99 |
| **TMMS0043** | *Paracloeodes* | 18 | 8 | 2.74 |
| **TMMS0043** | *Ulmeritoides* | 34 | 11 | 4.04 |
| **TMMS0058** | *Americabaetis* | 440 | 32 | 2.25 |
| **TMMS0058** | *Apobaetis* | 4 | 4 | 2.04 |
| **TMMS0058** | *Caenis* | 190 | 20 | 2.37 |
| **TMMS0058** | *Chimarra* | 26 | 22 | 5.82 |
| **TMMS0058** | *Leptonema* | 5 | 5 | 13.95 |
| **TMMS0058** | *Smicridea* | 55 | 36 | 4.97 |
| **TMMS0072** | *Caenis* | 53 | 18 | 2.64 |
| **TMMS0072** | *Leptonema* | 7 | 6 | 16.98 |
| **TMMS0072** | *Oxyetira* | 3 | 3 | 2.31 |
| **TMMS0072** | *Polyplectropus* | 6 | 4 | 7.40 |
| **TMMS0082** | *Campsurus* | 9 | 7 | 7.35 |
| **TMMS0088** | *Callibaetis* | 168 | 10 | 5.71 |
| **TMMS0088** | *Helicopsyche* | 11 | 5 | 3.72 |
| **TMMS0088** | *Tricorythodes* | 3 | 3 | 3.04 |
| **TMMS0088** | *Tricorythopsis* | 2 | 10 | 2.19 |
| **TMMS0090** | *Campylocia* | 17 | 16 | 7.84 |
| **TMMS0090** | *Miroculis* | 45 | 6 | 4.17 |
| **TMMS0090** | *Paracloeodes* | 19 | 4 | 2.68 |
| **TMMS0091** | *Aturbina* | 18 | 5 | 3.07 |
| **TMMS0091** | *Callibaetis* | 173 | 34 | 3.63 |
| **TMMS0091** | *Leptohyphes* | 6 | 6 | 2.95 |
| **TMMS0091** | *Oxyetira* | 11 | 6 | 1.83 |
| **TMMS0091** | *Traverhyphes* | 85 | 19 | 2.02 |
| **TMMS0119** | *Asthenopus* | 3 | 3 | 13.10 |
| **TMMS0119** | *Macrostemun* | 6 | 4 | 6.21 |
| **TMMS0126** | *Zelusia* | 11 | 7 | 3.52 |
| **TMMS0134** | *Miroculis* | 40 | 8 | 2.86 |
| **TMMS0134** | *Ulmeritoides* | 11 | 5 | 2.80 |
| **TMMS0137** | *Asthenopus* | 22 | 16 | 5.40 |
| **TMMS0159** | *Aturbina* | 28 | 19 | 2.72 |
| **TMMS0159** | *Callibaetis* | 60 | 7 | 4.30 |
| **TMMS0159** | *Latineosus* | 8 | 7 | 2.74 |
| **TMMS0159** | *Metrichia* | 15 | 13 | 1.75 |
| **TMMS0159** | *Oxyetira* | 8 | 6 | 1.69 |
| **TMMS0171** | *Hydrosmilodon* | 12 | 10 | 2.99 |
| **TMMS0171** | *Thraulodes* | 69 | 25 | 2.59 |
| **TMMS0171** | *Ulmeritoides* | 4 | 3 | 4.89 |
| **TMMS0178** | *Atopsyche* | 20 | 3 | 4.31 |

| Site | Taxon | Abundance | Count | Average size (cm) |
|---|---|---|---|---|
| **TMMS0178** | *Baetodes* | 60 | 17 | 1.86 |
| **TMMS0178** | *Cloeodes* | 74 | 16 | 2.54 |
| **TMMS0178** | *Farrodes* | 34 | 19 | 2.26 |
| **TMMS0178** | *Hydroptila* | 26 | 5 | 2.07 |
| **TMMS0178** | *Latineosus* | 12 | 12 | 2.84 |
| **TMMS0178** | *Metrichia* | 3 | 3 | 1.69 |
| **TMMS0178** | *Mortoniella* | 3 | 3 | 1.97 |
| **TMMS0178** | *Nectopsyche* | 18 | 8 | 3.43 |
| **TMMS0178** | *Thraulodes* | 52 | 19 | 1.95 |
| **TMMS0178** | *Traverhyphes* | 343 | 84 | 2.66 |
| **TMMS0183** | *Farrodes* | 9 | 8 | 2.02 |
| **TMMS0183** | *Hydrosmilodon* | 6 | 4 | 2.40 |
| **TMMS0183** | *Oecetis* | 4 | 3 | 2.13 |
| **TMMS0183** | *Polycentropus* | 6 | 3 | 3.75 |
| **TMMS0187** | *Asthenopus* | 16 | 13 | 5.49 |
| **TMMS0187** | *Cryptonympha* | 17 | 8 | 2.66 |
| **TMMS0187** | *Macronema* | 4 | 3 | 12.10 |
| **TMMS0187** | *Tricorythopsis* | 11 | 9 | 1.88 |
| **TMMS0193** | *Apobaetis* | 1 | 3 | 3.03 |
| **TMMS0209** | *Campsurus* | 30 | 25 | 3.64 |
| **TMMS0209** | *Polycentropus* | 36 | 9 | 6.29 |
| **TMMS0220** | *Cloeodes* | 129 | 9 | 2.71 |
| **TMMS0220** | *Smicridea* | 55 | 36 | 3.35 |
| **TMMS0220** | *Traverhyphes* | 869 | 93 | 2.59 |
| **TMMS0279** | *Polycentropus* | 7 | 3 | 4.74 |
| **TMMS0279** | *Tricorythopsis* | 21 | 10 | 1.86 |
| **TMMS0283** | *Americabaetis* | 213 | 82 | 2.47 |
| **TMMS0283** | *Atopsyche* | 11 | 3 | 6.40 |
| **TMMS0283** | *Farrodes* | 11 | 8 | 3.26 |
| **TMMS0283** | *Hermanella* | 6 | 6 | 3.15 |
| **TMMS0283** | *Leptohyphes* | 7 | 5 | 2.50 |
| **TMMS0283** | *Smicridea* | 8 | 24 | 3.46 |
| **TMMS0296** | *Caenis* | 39 | 22 | 2.13 |
| **TMMS0296** | *Campsurus* | 15 | 12 | 8.30 |
| **TMMS0296** | *Hydroptila* | 24 | 8 | 1.69 |
| **TMMS0296** | *Leptohyphes* | 13 | 12 | 1.70 |
| **TMMS0296** | *Metrichia* | 50 | 39 | 1.36 |
| **TMMS0296** | *Polyplectropus* | 10 | 5 | 4.80 |
| **TMMS0296** | *Smicridea* | 38 | 20 | 4.33 |
| **TMMS0296** | *Thraulodes* | 50 | 28 | 2.18 |
| **TMMS0296** | *Traverhyphes* | 171 | 49 | 3.91 |
| **TMMS0296** | *Tricorythodes* | 6 | 4 | 3.83 |
| **TMMS0391** | *Anchitrichia* | 3 | 3 | 4.71 |
| **TMMS0391** | *Cloeodes* | 10 | 5 | 4.32 |
| **TMMS0437** | *Americabaetis* | 620 | 76 | 2.37 |
| **TMMS0437** | *Apobaetis* | 28 | 8 | 2.50 |
| **TMMS0437** | *Asthenopus* | 6 | 5 | 6.82 |
| **TMMS0437** | *Campsurus* | 32 | 19 | 7.02 |
| **TMMS0437** | *Cyrnelus* | 12 | 6 | 4.92 |
| **TMMS0437** | *Farrodes* | 31 | 8 | 2.88 |
| **TMMS0437** | *Hydroptila* | 9 | 7 | 2.08 |
| **TMMS0437** | *Macronema* | 30 | 11 | 12.12 |
| **TMMS0437** | *Smicridea* | 37 | 18 | 6.63 |
| **TMMS0437** | *Waltzoyphius* | 198 | 24 | 3.41 |
| **TMMS1865** | *Asthenopus* | 6 | 5 | 7.66 |
| **TMMS1865** | *Callibaetis* | 67 | 19 | 5.08 |
| **TMMS1865** | *Simothraulopsis* | 5 | 3 | 5.31 |
| **TMMS1865** | *Waltzoyphius* | 35 | 15 | 3.30 |
| **TMMS3962** | *Caenis* | 38 | 14 | 2.64 |

| Site | Taxon | Abundance | Count | Average size (cm) |
|---|---|---|---|---|
| **TMMS3962** | *Oecetis* | 5 | 5 | 4.34 |
| **TMMS3962** | *Ulmeritoides* | 7 | 3 | 5.80 |
| **VGMS0002** | *Waltizoyphius* | 22 | 5 | 3.26 |
| **VGMS0004** | *Americabaetis* | 347 | 31 | 3.03 |
| **VGMS0004** | *Anacroneuria* | 65 | 20 | 6.70 |
| **VGMS0004** | *Austrotinodes* | 8 | 8 | 3.75 |
| **VGMS0004** | *Camelobaetidius* | 47 | 4 | 3.29 |
| **VGMS0004** | *Cloeodes* | 8 | 4 | 1.96 |
| **VGMS0004** | *Farrodes* | 606 | 75 | 2.32 |
| **VGMS0004** | *Hagenulopsis* | 92 | 28 | 1.55 |
| **VGMS0004** | *Hydroptila* | 77 | 23 | 1.82 |
| **VGMS0004** | *Leptohyphes* | 147 | 24 | 2.39 |
| **VGMS0004** | *Nectopsyche* | 4 | 3 | 2.14 |
| **VGMS0004** | *Thraulodes* | 84 | 31 | 4.20 |
| **VGMS0004** | *Ulmeritoides* | 47 | 3 | 1.69 |
| **VGMS0004** | *Zelusia* | 142 | 56 | 2.35 |
| **VGMS0016** | *Americabaetis* | 30 | 6 | 2.08 |
| **VGMS0016** | *Leptohyphes* | 11 | 3 | 2.60 |
| **VGMS0016** | *Nectopsyche* | 3 | 3 | 3.54 |
| **VGMS0016** | *Traverhyphes* | 17 | 13 | 2.31 |
| **VGMS0016** | *Ulmeritoides* | 8 | 6 | 5.32 |
| **VGMS0018** | *Polycentropus* | 7 | 6 | 4.15 |
| **VGMS0018** | *Smicridea* | 4 | 3 | 1.86 |
| **VGMS0018** | *Traverhyphes* | 16 | 5 | 3.83 |
| **VGMS0022** | *Alisotrichia* | 6 | 6 | 1.42 |
| **VGMS0022** | *Metrichia* | 4 | 4 | 1.95 |
| **VGMS0022** | *Phylloicus* | 123 | 75 | 3.59 |
| **VGMS0022** | *Smicridea* | 15 | 7 | 4.20 |
| **VGMS0022** | *Traverhyphes* | 20 | 13 | 2.83 |
| **VGMS0034** | *Caenis* | 73 | 35 | 2.83 |
| **VGMS0034** | *Cloeodes* | 34 | 8 | 2.19 |
| **VGMS0034** | *Leptohyphes* | 5 | 5 | 3.10 |
| **VGMS0034** | *Phylloicus* | 34 | 3 | 5.78 |
| **VGMS0034** | *Smicridea* | 22 | 14 | 3.30 |
| **VGMS0034** | *Traverhyphes* | 48 | 25 | 2.41 |
| **VGMS0044** | *Itaura* | 11 | 7 | 2.86 |
| **VGMS0044** | *Marilia* | 17 | 14 | 5.00 |
| **VGMS0044** | *Miroculis* | 51 | 27 | 4.23 |
| **VGMS0044** | *Paracloeodes* | 22 | 4 | 2.39 |
| **VGMS0044** | *Phylloicus* | 12 | 7 | 5.83 |
| **VGMS0044** | *Rivudiva* | 3 | 3 | 2.86 |
| **VGMS0044** | *Terpides* | 27 | 11 | 6.46 |
| **VGMS0044** | *Traverhyphes* | 7 | 5 | 3.24 |
| **VGMS0044** | *Tricorythodes* | 10 | 7 | 3.11 |
| **VGMS0044** | *Ulmeritoides* | 83 | 35 | 5.79 |
| **VGMS0048** | *Anacroneuria* | 36 | 13 | 4.66 |
| **VGMS0048** | *Smicridea* | 107 | 31 | 3.27 |
| **VGMS0080** | *Americabaetis* | 14 | 3 | 2.76 |
| **VGMS0109** | *Polycentropus* | 2 | 3 | 3.69 |
| **VGMS0109** | *Tricorythodes* | 20 | 10 | 2.27 |
| **VGMS0109** | *Waltizoyphius* | 10 | 4 | 2.92 |
| **VGMS0112** | *Hermanella* | 4 | 3 | 4.19 |
| **VGMS0112** | *Leptohyphes* | 20 | 13 | 2.64 |
| **VGMS0121** | *Farrodes* | 34 | 13 | 2.91 |
| **VGMS0121** | *Hagenulopsis* | 7 | 5 | 1.82 |
| **VGMS0124** | *Aturbina* | 20 | 13 | 2.90 |
| **VGMS0124** | *Paracloeodes* | 56 | 37 | 2.87 |
| **VGMS0124** | *Smicridea* | 3 | 3 | 4.70 |
| **VGMS0124** | *Ulmeritoides* | 13 | 6 | 1.84 |

| Site | Taxon | Abundance | Count | Average size (cm) |
|---|---|---|---|---|
| **VGMS0124** | *Waltizoyphius* | 10 | 4 | 5.29 |
| **VGMS0126** | *Oecetis* | 5 | 4 | 1.47 |
| **VGMS0126** | *Phylloicus* | 12 | 6 | 3.18 |
| **VGMS0162** | *Atopsyche* | 3 | 3 | 4.23 |
| **VGMS0162** | *Leptohyphes* | 16 | 9 | 2.21 |
| **VGMS0162** | *Marilia* | 3 | 3 | 4.68 |
| **VGMS0177** | *Atopsyche* | 3 | 3 | 4.81 |
| **VGMS0177** | *Neotrichia* | 10 | 3 | 1.23 |
| **VGMS0177** | *Oecetis* | 3 | 3 | 1.95 |
| **VGMS0177** | *Polycentropus* | 4 | 4 | 6.92 |
| **VGMS0191** | *Americabaetis* | 96 | 14 | 2.35 |
| **VGMS0191** | *Smicridea* | 280 | 12 | 2.63 |
| **VGMS0206** | *Caenis* | 90 | 41 | 2.37 |
| **VGMS0206** | *Hagenulopsis* | 8 | 4 | 1.97 |
| **VGMS0206** | *Leptohyphes* | 10 | 8 | 3.62 |
| **VGMS0206** | *Marilia* | 35 | 23 | 3.10 |
| **VGMS0206** | *Phylloicus* | 93 | 21 | 7.31 |
| **VGMS0206** | *Traverhyphes* | 90 | 25 | 2.90 |
| **VGMS0210** | *Caenis* | 21 | 13 | 2.57 |
| **VGMS0210** | *Cloeodes* | 126 | 18 | 2.47 |
| **VGMS0210** | *Leptohyphes* | 12 | 8 | 1.54 |
| **VGMS0210** | *Traverhyphes* | 35 | 9 | 2.30 |
| **VGMS0247** | *Anacroneuria* | 11 | 4 | 4.00 |
| **VGMS0255** | *Traverhyphes* | 13 | 7 | 2.42 |
| **VGMS0277** | *Phylloicus* | 7 | 6 | 8.34 |
| **VGMS0306** | *Anacroneuria* | 28 | 7 | 2.71 |
| **VGMS0306** | *Atopsyche* | 3 | 3 | 3.44 |
| **VGMS0306** | *Aturbina* | 72 | 24 | 2.44 |
| **VGMS0306** | *Caenis* | 31 | 16 | 3.13 |
| **VGMS0306** | *Cloeodes* | 88 | 8 | 2.29 |
| **VGMS0306** | *Itaura* | 121 | 24 | 2.23 |
| **VGMS0306** | *Leptohyphes* | 34 | 12 | 1.86 |
| **VGMS0306** | *Nectopsyche* | 4 | 4 | 3.38 |
| **VGMS0306** | *Paracloeodes* | 14 | 4 | 1.89 |
| **VGMS0306** | *Thraulodes* | 583 | 34 | 3.19 |
| **VGMS0306** | *Tricorythodes* | 49 | 10 | 3.12 |
| **VGMS0320** | *Smicridea* | 7 | 4 | 5.02 |
| **VGMS0380** | *Miroculis* | 32 | 13 | 2.80 |
| **VGMS0380** | *Oecetis* | 3 | 3 | 3.71 |
| **VGMS0380** | *Phylloicus* | 6 | 4 | 8.78 |
| **VGMS0380** | *Traverhyphes* | 38 | 26 | 3.26 |
| **VGMS0380** | *Tricorythodes* | 12 | 7 | 3.48 |
| **VGMS0380** | *Ulmeritoides* | 43 | 8 | 1.71 |
| **VGMS0387** | *Baetodes* | 30 | 14 | 1.72 |
| **VGMS0418** | *Atanatolia* | 6 | 5 | 3.58 |
| **VGMS0418** | *Atopsyche* | 26 | 19 | 3.54 |
| **VGMS0418** | *Caenis* | 7 | 3 | 2.37 |
| **VGMS0418** | *Hagenulopsis* | 23 | 3 | 2.77 |
| **VGMS0418** | *Leptohyphes* | 38 | 11 | 2.21 |
| **VGMS0418** | *Marilia* | 5 | 3 | 7.19 |
| **VGMS0418** | *Phylloicus* | 5 | 4 | 8.08 |
| **VGMS0418** | *Tricorythodes* | 78 | 31 | 1.92 |
| **VGMS0418** | *Waltizoyphius* | 25 | 3 | 2.49 |
| **VGMS0418** | *Zelusia* | 6 | 3 | 4.50 |
| **VGMS0433** | *Anacroneuria* | 26 | 17 | 4.50 |
| **VGMS0433** | *Atopsyche* | 4 | 5 | 2.88 |
| **VGMS0433** | *Zelusia* | 38 | 14 | 2.03 |
| **VGMS0444** | *Anacroneuria* | 26 | 4 | 1.40 |
| **VGMS0444** | *Apobaetis* | 44 | 18 | 2.56 |

| Site | Taxon | Abundance | Count | Average size (cm) |
|---|---|---|---|---|
| **VGMS0444** | *Aturbina* | 97 | 35 | 3.12 |
| **VGMS0444** | *Baetodes* | 510 | 39 | 1.79 |
| **VGMS0444** | *Camelobaetidius* | 32 | 4 | 2.35 |
| **VGMS0444** | *Chimarra* | 86 | 34 | 7.12 |
| **VGMS0444** | *Leptohyphes* | 380 | 80 | 2.14 |
| **VGMS0444** | *Nectopsyche* | 13 | 10 | 4.20 |
| **VGMS0444** | *Protoptila* | 32 | 15 | 2.64 |
| **VGMS0444** | *Terpides* | 10 | 5 | 3.78 |
| **VGMS0444** | *Traverhyphes* | 115 | 25 | 1.84 |
| **VGMS0444** | *Waltizoyphius* | 4 | 4 | 2.17 |
| **VGMS0511** | *Americabaetis* | 24 | 4 | 2.08 |
| **VGMS0515** | *Itaura* | 21 | 19 | 2.13 |
| **VGMS0515** | *Protoptila* | 8 | 4 | 2.47 |
| **VGMS0558** | *Chimarra* | 9 | 7 | 5.18 |
| **VGMS0558** | *Leptonema* | 36 | 6 | 14.51 |
| **VGMS0558** | *Protoptila* | 98 | 43 | 2.50 |
| **VGMS0558** | *Smicridea* | 210 | 38 | 3.50 |
| **VGMS0558** | *Wormaldia* | 3 | 3 | 6.70 |
| **VGMS0575** | *Phylloicus* | 14 | 7 | 3.99 |
| **SSMS0002** | *Latineosus* | 5 | 5 | 1.55 |
| **SSMS0002** | *Nectopsyche* | 35 | 4 | 2.90 |
| **SSMS0002** | *Phylloicus* | 52 | 19 | 3.79 |
| **SSMS0002** | *Polyplectropus* | 4 | 3 | 5.20 |
| **SSMS0002** | *Ulmeritoides* | 11 | 8 | 3.86 |
| **SSMS0008** | *Hagenulopsis* | 13 | 5 | 1.92 |
| **SSMS0008** | *Hydroptila* | 4 | 3 | 2.00 |
| **SSMS0008** | *Macronema* | 33 | 19 | 9.75 |
| **SSMS0008** | *Marilia* | 11 | 6 | 5.36 |
| **SSMS0008** | *Terpides* | 11 | 3 | 2.52 |
| **SSMS0008** | *Traverhyphes* | 35 | 12 | 3.21 |
| **SSMS0010** | *Smicridea* | 6 | 4 | 3.75 |
| **SSMS0014** | *Itaura* | 9 | 5 | 2.67 |
| **SSMS0028** | *Caenis* | 12 | 6 | 3.18 |
| **SSMS0028** | *Leptonema* | 3 | 3 | 12.89 |
| **SSMS0028** | *Traverhyphes* | 180 | 16 | 2.31 |
| **SSMS0029** | *Austrotinodes* | 3 | 3 | 2.51 |
| **SSMS0031** | *Macronema* | 131 | 13 | 9.79 |
| **SSMS0031** | *Marilia* | 4 | 3 | 5.81 |
| **SSMS0031** | *Miroculis* | 103 | 3 | 2.90 |
| **SSMS0031** | *Polycentropus* | 3 | 3 | 3.52 |
| **SSMS0031** | *Waltzoyphius* | 141 | 37 | 3.50 |
| **SSMS0031** | *Zelusia* | 68 | 21 | 2.34 |
| **SSMS0033** | *Protoptila* | 7 | 4 | 2.85 |
| **SSMS0033** | *Smicridea* | 686 | 66 | 3.14 |
| **SSMS0035** | *Mortoniella* | 3 | 3 | 2.58 |
| **SSMS0035** | *Rivudiva* | 6 | 5 | 3.28 |
| **SSMS0037** | *Callibaetis* | 53 | 23 | 3.80 |
| **SSMS0037** | *Paracloeodes* | 48 | 3 | 2.44 |
| **SSMS0037** | *Phylloicus* | 10 | 6 | 5.00 |
| **SSMS0037** | *Protoptila* | 8 | 6 | 2.21 |
| **SSMS0038** | *Smicridea* | 13 | 7 | 2.36 |
| **SSMS0044** | *Caenis* | 7 | 5 | 2.23 |
| **SSMS0053** | *Americabaetis* | 27 | 6 | 4.12 |
| **SSMS0053** | *Anacroneuria* | 8 | 14 | 5.73 |
| **SSMS0053** | *Polyplectropus* | 4 | 3 | 4.13 |
| **SSMS0053** | *Rivudiva* | 18 | 3 | 3.77 |
| **SSMS0057** | *Baetodes* | 4 | 3 | 1.58 |
| **SSMS0057** | *Caenis* | 33 | 5 | 3.40 |
| **SSMS0057** | *Chimarra* | 32 | 22 | 5.09 |

| Site | Taxon | Abundance | Count | Average size (cm) |
|---|---|---|---|---|
| **SSMS0057** | *Polycentropus* | 3 | 3 | 5.13 |
| **SSMS0057** | *Smicridea* | 84 | 29 | 3.91 |
| **SSMS0073** | *Protoptila* | 22 | 12 | 2.55 |
| **SSMS0073** | *Smicridea* | 124 | 31 | 3.61 |
| **SSMS0078** | *Anacroneuria* | 14 | 6 | 4.94 |
| **SSMS0078** | *Leptonema* | 5 | 3 | 16.80 |
| **SSMS0094** | *Anacroneuria* | 16 | 3 | 5.38 |
| **SSMS0094** | *Itaura* | 12 | 3 | 1.78 |
| **SSMS0094** | *Polyplectropus* | 23 | 18 | 4.94 |
| **SSMS0094** | *Thraulodes* | 118 | 22 | 3.01 |
| **SSMS0094** | *Tricorythodes* | 42 | 7 | 2.25 |
| **SSMS0129** | *Caenis* | 17 | 5 | 4.81 |
| **SSMS0133** | *Helicopsyche* | 14 | 8 | 3.15 |
| **SSMS0133** | *Hydroptila* | 160 | 57 | 1.85 |
| **SSMS0133** | *Macronema* | 6 | 4 | 4.74 |
| **SSMS0133** | *Oxyetira* | 21 | 16 | 1.81 |
| **SSMS0133** | *Polyplectropus* | 6 | 3 | 5.02 |
| **SSMS0133** | *Rivudiva* | 6 | 5 | 3.71 |
| **SSMS0133** | *Smicridea* | 35 | 21 | 4.03 |
| **SSMS0133** | *Tricorythodes* | 33 | 10 | 3.71 |
| **SSMS0133** | *Tricorythopsis* | 6 | 6 | 1.52 |
| **SSMS0144** | *Polyplectropus* | 3 | 3 | 6.02 |
| **SSMS0149** | *Austrotinodes* | 6 | 7 | 3.30 |
| **SSMS0149** | *Helicopsyche* | 5 | 3 | 4.80 |
| **SSMS0150** | *Anacroneuria* | 8 | 4 | 6.06 |
| **SSMS0150** | *Leptohyphes* | 12 | 3 | 3.58 |
| **SSMS0157** | *Miroculis* | 18 | 11 | 2.73 |
| **SSMS0157** | *Nyctiophylax* | 3 | 3 | 2.04 |
| **SSMS0157** | *Phylloicus* | 66 | 36 | 3.27 |
| **SSMS0157** | *Polycentropus* | 7 | 6 | 4.11 |
| **SSMS0157** | *Triplectides* | 3 | 3 | 2.55 |
| **SSMS0175** | *Anacroneuria* | 144 | 20 | 5.38 |
| **SSMS0175** | *Baetodes* | 341 | 13 | 1.45 |
| **SSMS0175** | *Chimarra* | 182 | 26 | 3.85 |
| **SSMS0175** | *Farrodes* | 46 | 14 | 2.67 |
| **SSMS0175** | *Hagenulopsis* | 6 | 4 | 1.93 |
| **SSMS0175** | *Leptohyphes* | 164 | 3 | 2.46 |
| **SSMS0175** | *Leptonema* | 12 | 3 | 15.07 |
| **SSMS0175** | *Phylloicus* | 8 | 5 | 3.82 |
| **SSMS0175** | *Protoptila* | 6 | 3 | 2.75 |
| **SSMS0175** | *Smicridea* | 133 | 18 | 3.08 |
| **SSMS0175** | *Thraulodes* | 300 | 18 | 3.42 |
| **SSMS0175** | *Wormaldia* | 38 | 28 | 1.87 |
| **SSMS0191** | *Anacroneuria* | 13 | 9 | 6.09 |
| **SSMS0191** | *Chimarra* | 10 | 9 | 3.76 |
| **SSMS0191** | *Farrodes* | 118 | 35 | 2.59 |
| **SSMS0191** | *Helicopsyche* | 23 | 6 | 4.25 |
| **SSMS0191** | *Miroculis* | 7 | 5 | 2.52 |
| **SSMS0191** | *Traverhyphes* | 7 | 6 | 2.56 |
| **SSMS0193** | *Anacroneuria* | 4 | 4 | 2.41 |
| **SSMS0193** | *Caenis* | 153 | 62 | 2.63 |
| **SSMS0193** | *Leptonema* | 4 | 3 | 16.00 |
| **SSMS0193** | *Tikuna* | 3 | 3 | 3.33 |
| **SSMS0193** | *Traverhyphes* | 87 | 33 | 2.52 |
| **SSMS0193** | *Tricorythodes* | 48 | 26 | 2.39 |
| **SSMS0199** | *Helicopsyche* | 10 | 4 | 3.22 |
| **SSMS0199** | *Polycentropus* | 4 | 4 | 4.01 |
| **SSMS0213** | *Aturbina* | 4 | 3 | 2.87 |
| **SSMS0213** | *Camelobaetidius* | 44 | 3 | 1.39 |

| Site | Taxon | Abundance | Count | Average size (cm) |
|---|---|---|---|---|
| **SSMS0213** | *Hydrosmilodon* | 19 | 6 | 2.51 |
| **SSMS0213** | *Protoptila* | 6 | 3 | 2.45 |
| **SSMS0351** | *Farrodes* | 107 | 29 | 2.65 |
| **SSMS0351** | *Helicopsyche* | 7 | 6 | 2.76 |
| **SSMS0351** | *Hydrosmilodon* | 23 | 7 | 2.04 |
| **SSMS0351** | *Leptonema* | 13 | 5 | 13.86 |
| **SSMS0351** | *Phylloicus* | 3 | 3 | 10.97 |
| **SSMS0351** | *Terpides* | 10 | 6 | 4.67 |
| **SSMS0351** | *Thraulodes* | 141 | 11 | 3.13 |
| **SSMS0351** | *Traverhyphes* | 47 | 21 | 3.03 |
| **SSMS0408** | *Smicridea* | 13 | 4 | 5.78 |
| **SSMS0411** | *Americabaetis* | 368 | 41 | 1.82 |
| **SSMS0411** | *Anacroneuria* | 6 | 5 | 4.05 |
| **SSMS0411** | *Aturbina* | 50 | 18 | 2.42 |
| **SSMS0411** | *Caenis* | 10 | 7 | 3.72 |
| **SSMS0411** | *Latineosus* | 10 | 12 | 3.06 |
| **SSMS0411** | *Leptohyphes* | 14 | 10 | 2.21 |
| **SSMS0411** | *Metrichia* | 29 | 15 | 2.34 |
| **SSMS0411** | *Nectopsyche* | 11 | 8 | 2.81 |
| **SSMS0411** | *Rivudiva* | 7 | 26 | 3.23 |
| **SSMS0411** | *Traverhyphes* | 78 | 31 | 2.77 |
| **SSMS0411** | *Ulmeritoides* | 12 | 7 | 4.87 |
| **SSMS1000** | *Baetodes* | 61 | 7 | 1.81 |
| **SSMS1000** | *Macronema* | 7 | 4 | 2.52 |
| **SSMS1000** | *Smicridea* | 20 | 6 | 2.10 |
| **SSMS4173** | *Smicridea* | 439 | 66 | 4.27 |
| **SSMS4330** | *Phylloicus* | 3 | 3 | 9.87 |
| **SSMS4330** | *Traverhyphes* | 52 | 30 | 2.44 |
| **RENP0008** | *Anacroneuria* | 10 | 5 | 10.60 |
| **RENP0008** | *Barypenthus* | 9 | 8 | 8.80 |
| **RENP0012** | *Macrostemun* | 3 | 4 | 9.93 |
| **RENP0012** | *Smicridea* | 31 | 4 | 4.98 |
| **RENP0012** | *Tricorythopsis* | 73 | 7 | 1.57 |
| **RENP0016** | *Atopsyche* | 6 | 5 | 6.46 |
| **RENP0016** | *Farrodes* | 15 | 9 | 3.14 |
| **RENP0016** | *Hydroptila* | 6 | 4 | 1.86 |
| **RENP0016** | *Marilia* | 3 | 3 | 5.38 |
| **RENP0016** | *Miroculis* | 13 | 9 | 3.03 |
| **RENP0016** | *Polyplectropus* | 8 | 6 | 5.22 |
| **RENP0016** | *Thraulodes* | 153 | 77 | 3.53 |
| **RENP0052** | *Paragrypopteryx* | 59 | 33 | 2.07 |
| **RENP0052** | *Tupiperla* | 9 | 5 | 3.29 |
| **RENP0054** | *Leptohyphes* | 3 | 4 | 4.99 |
| **RENP0054** | *Leptohyphodes* | 9 | 8 | 5.44 |
| **RENP0075** | *Anacroneuria* | 36 | 17 | 3.08 |
| **RENP0075** | *Atopsyche* | 8 | 9 | 5.10 |
| **RENP0075** | *Campylocia* | 3 | 3 | 16.21 |
| **RENP0075** | *Leptonema* | 11 | 6 | 9.06 |
| **RENP0075** | *Marilia* | 12 | 6 | 6.30 |
| **RENP0075** | *Polyplectropus* | 21 | 9 | 6.20 |
| **RENP0075** | *Tricorythopsis* | 74 | 13 | 1.71 |
| **RENP0092** | *Caenis* | 33 | 9 | 2.76 |
| **RENP0092** | *Smicridea* | 42 | 12 | 5.30 |
| **RENP0095** | *Marilia* | 11 | 5 | 5.49 |
| **RENP0095** | *Phylloicus* | 29 | 13 | 6.92 |
| **RENP0095** | *Tricorythodes* | 17 | 16 | 2.80 |
| **RENP0095** | *Tupiperla* | 18 | 4 | 4.02 |
| **RENP0096** | *Farrodes* | 5 | 3 | 2.00 |
| **RENP0096** | *Smicridea* | 20 | 8 | 4.20 |

| Site | Taxon | Abundance | Count | Average size (cm) |
|---|---|---|---|---|
| **RENP0097** | *Farrodes* | 16 | 10 | 2.77 |
| **RENP100** | *Callibaetis* | 6 | 5 | 6.56 |
| **RENP100** | *Farrodes* | 17 | 11 | 2.74 |
| **RENP100** | *Hagenulopsis* | 58 | 38 | 3.67 |
| **RENP100** | *Itaura* | 51 | 22 | 1.87 |
| **RENP100** | *Marilia* | 6 | 3 | 5.07 |
| **RENP100** | *Miroculis* | 17 | 12 | 3.83 |
| **RENP100** | *Nectopsyche* | 11 | 6 | 4.15 |
| **RENP100** | *Thraulodes* | 211 | 17 | 3.06 |
| **RENP100** | *Tupiperla* | 4 | 3 | 4.60 |
| **RENP0108** | *Leptonema* | 27 | 16 | 4.31 |
| **RENP0108** | *Paragrypopteryx* | 35 | 20 | 2.05 |
| **RENP0108** | *Phylloicus* | 7 | 6 | 6.10 |
| **RENP0108** | *Tricorythodes* | 5 | 5 | 3.18 |
| **RENP0108** | *Tupiperla* | 101 | 44 | 3.80 |
| **RENP0110** | *Americabaetis* | 65 | 103 | 2.87 |
| **RENP0110** | *Neotrichia* | 2 | 5 | 1.33 |
| **RENP0112** | *Anacroneuria* | 20 | 7 | 2.96 |
| **RENP0112** | *Austrotinodes* | 8 | 5 | 3.21 |
| **RENP0112** | *Caenis* | 191 | 93 | 2.58 |
| **RENP0112** | *Callibaetis* | 6 | 5 | 4.32 |
| **RENP0112** | *Traverhyphes* | 146 | 55 | 2.85 |
| **RENP0112** | *Zelusia* | 45 | 7 | 3.79 |
| **RENP0132** | *Tupiperla* | 106 | 77 | 3.44 |
| **RENP0139** | *Leptonema* | 10 | 6 | 7.94 |
| **RENP0139** | *Smicridea* | 7 | 3 | 2.34 |
| **RENP0144** | *Americabaetis* | 23 | 11 | 2.01 |
| **RENP0144** | *Aturbina* | 56 | 32 | 3.86 |
| **RENP0144** | *Baetodes* | 16 | 13 | 1.67 |
| **RENP0144** | *Callibaetis* | 5 | 4 | 4.57 |
| **RENP0144** | *Cloeodes* | 6 | 4 | 3.35 |
| **RENP0144** | *Farrodes* | 8 | 5 | 2.40 |
| **RENP0144** | *Marilia* | 5 | 3 | 5.97 |
| **RENP0144** | *Miroculis* | 13 | 8 | 3.54 |
| **RENP0144** | *Paracloeodes* | 91 | 45 | 3.19 |
| **RENP0144** | *Tupiperla* | 3 | 3 | 3.70 |
| **RENP0144** | *Zelusia* | 6 | 4 | 2.80 |
| **RENP0187** | *Paragrypopteryx* | 4 | 3 | 1.92 |
| **RENP0187** | *Tricorythopsis* | 35 | 4 | 1.91 |
| **RENP0203** | *Camelobaetidius* | 6 | 3 | 3.75 |
| **RENP0203** | *Leptonema* | 14 | 8 | 12.11 |
| **RENP0203** | *Traverhyphes* | 637 | 148 | 2.78 |
| **RENP0203** | *Tricorythopsis* | 219 | 73 | 1.93 |
| **RENP0203** | *Tupiperla* | 7 | 3 | 2.21 |
| **RENP0228** | *Grypopteryx* | 9 | 9 | 3.27 |
| **RENP0240** | *Askola* | 10 | 9 | 4.04 |
| **RENP0251** | *Americabaetis* | 26 | 5 | 1.99 |
| **RENP0251** | *Grypopteryx* | 7 | 6 | 1.95 |
| **RENP0251** | *Kempnya* | 3 | 3 | 7.12 |
| **RENP0251** | *Metrichia* | 7 | 6 | 1.86 |
| **RENP0251** | *Paragrypopteryx* | 12 | 11 | 1.62 |
| **RENP0251** | *Tupiperla* | 15 | 3 | 2.05 |
| **RENP0287** | *Callibaetis* | 155 | 40 | 4.89 |
| **RENP0287** | *Farrodes* | 75 | 23 | 3.76 |
| **RENP0287** | *Massartella* | 14 | 14 | 5.16 |
| **RENP0287** | *Miroculis* | 5 | 3 | 5.63 |
| **RENP0287** | *Oecetis* | 4 | 3 | 3.16 |
| **RENP0287** | *Paracloeodes* | 34 | 6 | 2.81 |
| **RENP0287** | *Paragrypopteryx* | 7 | 5 | 1.72 |

| Site | Taxon | Abundance | Count | Average size (cm) |
|---|---|---|---|---|
| **RENP0287** | *Phylloicus* | 17 | 5 | 4.52 |
| **RENP0287** | *Smicridea* | 56 | 23 | 4.88 |
| **RENP0287** | *Triplectides* | 8 | 3 | 5.46 |
| **RENP0287** | *Tupiperla* | 113 | 28 | 3.79 |
| **RENP0375** | *Atopsyche* | 5 | 4 | 8.24 |
| **RENP0375** | *Hagenulopsis* | 11 | 8 | 3.02 |
| **RENP0375** | *Smicridea* | 11 | 5 | 4.58 |
| **RENP0443** | *Itaura* | 20 | 8 | 2.09 |
| **RENP0443** | *Zelusia* | 3 | 3 | 2.63 |
| **RENP0511** | *Itaura* | 119 | 22 | 2.24 |
| **RENP0511** | *Oecetis* | 9 | 7 | 2.07 |
| **RENP0511** | *Protoptila* | 64 | 23 | 2.55 |
| **RENP0511** | *Tricorythopsis* | 88 | 19 | 1.48 |
| **RENP1524** | *Askola* | 6 | 6 | 3.08 |
| **RENP1524** | *Itaura* | 13 | 5 | 2.38 |
| **RENP1524** | *Leptonema* | 6 | 3 | 10.10 |
| **RENP1524** | *Marilia* | 27 | 9 | 3.67 |
| **RENP2991** | *Americabaetis* | 150 | 54 | 4.41 |
| **RENP2991** | *Atopsyche* | 24 | 9 | 4.40 |
| **RENP2991** | *Cryptonympha* | 14 | 3 | 3.42 |
| **RENP2991** | *Itaura* | 27 | 13 | 1.88 |
| **RENP2991** | *Paracloeodes* | 26 | 10 | 2.40 |
| **RENP2991** | *Waltzoyphius* | 14 | 8 | 4.09 |
| **RENP7308** | *Askola* | 11 | 4 | 3.17 |
| **RENP7308** | *Barypenthus* | 4 | 3 | 11.05 |
| **RENP7308** | *Campylocia* | 14 | 13 | 10.01 |
| **RENP7308** | *Farrodes* | 13 | 6 | 3.25 |
| **RENP7308** | *Hagenulopsis* | 8 | 4 | 3.92 |
| **RENP7308** | *Leptohyphodes* | 7 | 6 | 7.10 |
| **RENP7308** | *Massartella* | 23 | 20 | 7.00 |
| **RENP7308** | *Miroculis* | 26 | 9 | 3.71 |
| **RENP7308** | *Phylloicus* | 13 | 3 | 5.16 |
| **RENP7308** | *Triplectides* | 42 | 4 | 8.11 |
| **RENP7308** | *Tupiperla* | 25 | 16 | 3.50 |
| **RENP7308** | *Ulmeritoides* | 59 | 41 | 3.83 |
| **RENP9611** | *Leptonema* | 8 | 3 | 11.37 |
| **RENP9611** | *Phylloicus* | 5 | 5 | 9.45 |
| **RENP9611** | *Triplectides* | 17 | 6 | 10.89 |
| **RENP9611** | *Tupiperla* | 11 | 6 | 6.12 |
| **RENP12892** | *Oxyetira* | 128 | 41 | 2.60 |
| **RENP12892** | *Smicridea* | 49 | 34 | 3.84 |

**Appendix 5**: Geographic coordinates (pseudo-mercator) of each sampling site.

| | XN | YN |
|---|---|---|
| **TMMS0003** | -5004750 | -2126023 |
| **TMMS0007** | -4972390 | -2145335 |
| **TMMS0009** | -5072223 | -2136948 |
| **TMMS0027** | -5008322 | -2091517 |
| **TMMS0028** | -5087172 | -2153538 |
| **TMMS0033** | -5050820 | -2182975 |
| **TMMS0040** | -5084544 | -2166847 |
| **TMMS0043** | -5008248 | -2084999 |
| **TMMS0058** | -5028051 | -2164074 |
| **TMMS0072** | -5084166 | -2088968 |
| **TMMS0082** | -5059776 | -2165143 |
| **TMMS0088** | -5077452 | -2101090 |
| **TMMS0090** | -5032387 | -2177727 |
| **TMMS0091** | -5011468 | -2098094 |
| **TMMS0106** | -5025505 | -2167614 |
| **TMMS0119** | -4990320 | -2123820 |
| **TMMS0126** | -5010063 | -2140963 |
| **TMMS0133** | -5035765 | -2181756 |
| **TMMS0134** | -5011200 | -2156475 |
| **TMMS0137** | -5068465 | -2129999 |
| **TMMS0159** | -5009753 | -2075817 |
| **TMMS0171** | -5022241 | -2076486 |
| **TMMS0178** | -5037971 | -2154479 |
| **TMMS0183** | -4985081 | -2135849 |
| **TMMS0187** | -5022757 | -2089236 |
| **TMMS0193** | -5066444 | -2192409 |
| **TMMS0209** | -5056364 | -2185712 |
| **TMMS0214** | -5012401 | -2164986 |
| **TMMS0220** | -5080251 | -2149399 |
| **TMMS0279** | -4975397 | -2159685 |
| **TMMS0283** | -5010553 | -2083446 |
| **TMMS0290** | -5059075 | -2176289 |
| **TMMS0296** | -5080568 | -2161000 |
| **TMMS0391** | -4967616 | -2148333 |
| **TMMS0437** | -5070297 | -2140772 |
| **TMMS1865** | -5066888 | -2128753 |
| **TMMS3195** | -5032925 | -2065596 |
| **TMMS3962** | -5004644 | -2111141 |
| **VGMS00002** | -5326258 | -2244702 |
| **VGMS00004** | -5318625 | -2287935 |
| **VGMS00016** | -5340011 | -2261589 |
| **VGMS00018** | -5312304 | -2248158 |
| **VGMS00022** | -5306571 | -2253297 |
| **VGMS00034** | -5323168 | -2243889 |
| **VGMS00037** | -5345010 | -2266346 |
| **VGMS00044** | -5341554 | -2252390 |
| **VGMS00048** | -5356907 | -2261993 |
| **VGMS00080** | -5346036 | -2263545 |
| **VGMS00109** | -5322995 | -2255848 |
| **VGMS00112** | -5353010 | -2263343 |
| **VGMS00121** | -5332599 | -2260880 |
| **VGMS00124** | -5351154 | -2247651 |
| **VGMS00126** | -5313693 | -2307859 |
| **VGMS00128** | -5368684 | -2258779 |
| **VGMS00162** | -5321331 | -2250967 |
| **VGMS00177** | -5356053 | -2271250 |
| **VGMS00191** | -5323158 | -2282967 |
| **VGMS00206** | -5314518 | -2293294 |
| **VGMS00210** | -5320238 | -2243733 |

| | XN | YN |
|---|---|---|
| **VGMS00247** | -5310177 | -2311374 |
| **VGMS00252** | -5339644 | -2265206 |
| **VGMS00255** | -5317948 | -2282474 |
| **VGMS00277** | -5340319 | -2267512 |
| **VGMS00306** | -5321099 | -2247594 |
| **VGMS00320** | -5352835 | -2248199 |
| **VGMS00380** | -5353615 | -2251879 |
| **VGMS00387** | -5324336 | -2308152 |
| **VGMS00418** | -5319546 | -2247685 |
| **VGMS00433** | -5353179 | -2269349 |
| **VGMS00444** | -5339265 | -2259219 |
| **VGMS00447** | -5321195 | -2280954 |
| **VGMS00450** | -5311717 | -2252843 |
| **VGMS00511** | -5317390 | -2284070 |
| **VGMS00515** | -5318759 | -2306905 |
| **VGMS00558** | -5314345 | -2298670 |
| **VGMS00575** | -5315793 | -2285833 |
| **SSMS0001** | -5659094 | -2124221 |
| **SSMS0002** | -5515157 | -2145194 |
| **SSMS0008** | -5495045 | -2079551 |
| **SSMS0010** | -5603289 | -2160963 |
| **SSMS0014** | -5637589 | -2121498 |
| **SSMS0028** | -5541379 | -2094286 |
| **SSMS0029** | -5549126 | -2131715 |
| **SSMS0031** | -5631492 | -2101506 |
| **SSMS0033** | -5555716 | -2158091 |
| **SSMS0035** | -5639297 | -2137661 |
| **SSMS0037** | -5532310 | -2134461 |
| **SSMS0038** | -5571472 | -2150876 |
| **SSMS0044** | -5524368 | -2078213 |
| **SSMS0051** | -5569751 | -2061765 |
| **SSMS0053** | -5532425 | -2151622 |
| **SSMS0057** | -5556096 | -2152442 |
| **SSMS0059** | -5627459 | -2081248 |
| **SSMS0073** | -5524773 | -2116908 |
| **SSMS0078** | -5652950 | -2121606 |
| **SSMS0094** | -5639594 | -2130108 |
| **SSMS0105** | -5566612 | -2135756 |
| **SSMS0126** | -5631319 | -2122483 |
| **SSMS0129** | -5561747 | -2159236 |
| **SSMS0133** | -5525438 | -2163278 |
| **SSMS0144** | -5558142 | -2072888 |
| **SSMS0149** | -5541030 | -2152985 |
| **SSMS0150** | -5576997 | -2145713 |
| **SSMS0157** | -5511353 | -2133206 |
| **SSMS0175** | -5621549 | -2107708 |
| **SSMS0191** | -5639510 | -2082252 |
| **SSMS0193** | -5561676 | -2159509 |
| **SSMS0199** | -5576777 | -2066224 |
| **SSMS0213** | -5541996 | -2149359 |
| **SSMS0351** | -5625084 | -2098036 |
| **SSMS0408** | -5519969 | -2108761 |
| **SSMS0411** | -5607935 | -2079929 |
| **SSMS0447** | -5639767 | -2085368 |
| **SSMS1000** | -5522800 | -2117123 |
| **SSMS4173** | -5507053 | -2150245 |
| **SSMS4330** | -5508137 | -2095185 |
| **RENP0008** | -5292426 | -2191103 |
| **RENP0012** | -5256157 | -2197289 |
| **RENP0016** | -5231073 | -2179757 |

| | XN | YN |
|---|---|---|
| **RENP0028** | -5256068 | -2182408 |
| **RENP0047** | -5219796 | -2207514 |
| **RENP0052** | -5304098 | -2202266 |
| **RENP0054** | -5237765 | -2174212 |
| **RENP0055** | -5217844 | -2156991 |
| **RENP0075** | -5235806 | -2169793 |
| **RENP0092** | -5260559 | -2191396 |
| **RENP0095** | -5211962 | -2186358 |
| **RENP0096** | -5241390 | -2167891 |
| **RENP0097** | -5262994 | -2151548 |
| **RENP0100** | -5236062 | -2179200 |
| **RENP0108** | -5245483 | -2191019 |
| **RENP0110** | -5284615 | -2230633 |
| **RENP0112** | -5247826 | -2141550 |
| **RENP0128** | -5272763 | -2157352 |
| **RENP0132** | -5230236 | -2181848 |
| **RENP0139** | -5239032 | -2147196 |
| **RENP0144** | -5260715 | -2159241 |
| **RENP0187** | -5213329 | -2201635 |
| **RENP0192** | -5289152 | -2186340 |
| **RENP0203** | -5212728 | -2169410 |
| **RENP0228** | -5306756 | -2197490 |
| **RENP0240** | -5278006 | -2183970 |
| **RENP0251** | -5214100 | -2208390 |
| **RENP0287** | -5212948 | -2192923 |
| **RENP0368** | -5245003 | -2146950 |
| **RENP0375** | -5222965 | -2163384 |
| **RENP0443** | -5217826 | -2203409 |
| **RENP0511** | -5238956 | -2203579 |
| **RENP1524** | -5296415 | -2187214 |
| **RENP2991** | -5230937 | -2218142 |
| **RENP5612** | -5284042 | -2197789 |
| **RENP7308** | -5248663 | -2182152 |
| **RENP9611** | -5247646 | -2184062 |
| **RENP9757** | -5224006 | -2224989 |
| **RENP12892** | -5260215 | -2190168 |
| **RENP15048** | -5290278 | -2191936 |