THESIS

STUDIES ON THE ODONATA AND TRICHOPTERA OF HIGH-ELEVATION LAKES OF NORTHERN COLORADO AND SOUTHERN WYOMING

Submitted by

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ABSTRACT

STUDIES ON THE ODONATA AND TRICHOPTERA OF THE HIGH-ELEVATION LAKES OF NORTHERN COLORADO AND SOUTHERN WYOMING

Freshwater biodiversity loss is a major concern, and global warming is already causing a significant role in species extinctions. The main goal of this research was to provide a baseline for specific aquatic insect species distributions at high-elevation lentic habitats in Northcentral Colorado and Southern Wyoming.

I provided occurrence records of the Hudsonian Emerald dragonfly (*Somatochlora hudsonica,* HED) in Northcentral Colorado and Southern Wyoming. The HED is the only Colorado dragonfly listed as threatened by the US Forest Service. It was ranked as critically imperiled in Colorado and vulnerable in Wyoming. I used Maxent (Maximum entropy), a machine learning program that uses species presence data and environmental variables to predict the potentially suitable habitat for species. Maxent was used to plot a map of the potentially suitable habitats of HED. Temperature seasonality, mean temperature of wettest quarter, precipitation of warmest quarter, precipitation of driest quarter, and precipitation seasonality were the key environmental factors for predicting the occurrence of HED in appropriate high-elevation lakes of Northcentral Colorado and Southern Wyoming with an accumulated contribution of 91%. Results of this study provided baseline data for the US Forest Service to assist to evaluate the conservation status of HED and potentially initiate protection plans in two national forests (The Arapaho & Roosevelt National Forest and the Medicine Bow & Routt National Forest) in Colorado and Wyoming.

I report adult caddisflies from 136 montane and alpine lentic habitats, primarily lakes, of seven northern Colorado counties for the first time. My objective was to provide species records of adult and larval caddisflies from high-altitude lentic habitats that are not generally well sampled. These lakes may be potentially impacted by current and future global climate change scenarios. Field collection of adults and rearing of larvae were included with available unpublished and published records, resulting in 541 confirmed records of caddisfly species.

Forty-nine species, representing 24% of all known Colorado caddisflies are documented. Seven families and 24 genera are represented. The Limnephilidae comprised 76% of the 49 recorded species. The other six families were usually represented by only one to four species. Distribution maps are presented for the six families and the most common limnephilid species.

Montane and alpine lakes are vulnerable ecosystems likely to be impacted by climate change. Comprehensive faunal surveys are key to understanding long–term biodiversity changes and establishing conservation needs and priorities. In addition, species lists of taxa are important to monitor future faunal biodiversity changes.

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DEDICATION

To my family, who encouraged and prayed for me to follow my passion and always believed in my success.

TABLE OF CONTENTS

CHAPTER ONE: STUDIES ON THE ODONATA AND TRICHOPTERA OF THE HIGH-ELEVATION LAKES OF NORTHERN COLORADO AND SOUTHERN WYOMING

Freshwater ecosystems are considered the most threatened on earth, although they are major suppliers of ecosystem services (ME Assessment 2005), and are highly affected by climate change, pollution, and habitat degradation across all organization scales, from community composition to genetic diversity (Kalkman et al. 2008, Bush et al. 2014a). Extinction rates for aquatic species are substantially higher than for other taxonomic groups (Hambler et al. 2011, Wiens 2016), which has already and will likely result in additional future losses to freshwater invertebrate biodiversity (Strayer 2006, Hambler et al. 2011, Reid et al. 2019).

Human activities are estimated to have increased global temperatures by approximately 1.5ºC (IPCC 2018). Climate-induced changes to habitats are expected to result in biodiversity loss of amphibians (Yiming et al. 2013), birds (Julliard et al. 2004), insects (Hering et al. 2009, Pureswaran et al. 2018, Kellermann and van Heerwaarden 2019, Wagner 2020, Timoner et al. 2021, Basel et al. 2021), plants (Li et al. 2020), spiders (Mammola et al. 2018), and other various different taxonomic groups (Williams et al. 2015). Understanding habitat requirements and species distribution is key to conserve species under climate change scenarios (Pires et al. 2018). Identification of conservation units or taxa with information on their biodiversity patterns and connections between ecosystems are key to sustaining biological processes and ecosystem services, helping to prevent biodiversity loss (Margules and Sarker 2007).

Insects are considered the dominant taxon in most freshwater ecosystems (Resh & Rosenberg 1989). Phenology and timing of key physiological events (emergence, survivorship, growth, mating, and geographic distribution) of aquatic insects are strongly linked to temperature patterns of the water environment in which taxa evolved, and they are suited to assess the effects of global climate change (Hering et al. 2009, Bush et al. 2014b). Many studies had predicted and recorded the decline of freshwater insects (Hering et al. 2009, Hamilton et al. 2010, Domisch et al. 2012, Bush et al. 2014a, Shah et al. 2017, Rocha-Ortega et al. 2020, Timoner et al. 2021) as a result of anthropogenic effects and climate change. For example, Hamilton et al. (2010) predicted a decrease of 30-40% of Ephemeroptera, Plecoptera, and Trichoptera species richness in Maine and Utah (USA). European aquatic invertebrates are predicted to decline by 57% by the year 2080 (Domisch et al. 2012). In their modelling of 270 Australian Odonata species, Bush et al. (2014b) found that between 56 and 59% of species are predicted to experience an overall decline in habitat by 2085. Species richness of Ephemeroptera, Plecoptera, and Trichoptera of Switzerland rivers are expected to decline at least by 8% as a result of global warming (Timoner et al. 2021).

Knowledge of the occurrence and diversity of freshwater insects still insufficient due to the lack of formal description and distribution for many species (Dinz-Filho et al. 2010). Understanding species spatial distribution is a key to biodiversity conservation (Anderson et al. 2003). Species Distribution Models (SDMs) are widely used in ecological studies for predicting species geographical distribution (Guisan et al. 2000, Peterson et al. 2012). Species Distribution Models use climate, biological, and topographic data to define species distribution ranges and potential distribution spatially (Phillips and Dudik 2008, Peterson et al. 2012, Young et al. 2019). They have been successfully used for wildlife species studies (Thorn et al. 2009, Kalboussi and Achour 2018), invasive species (Kumar et al. 2009), plants (Kumar & Stohlgren 2009, Kumar 2012), and insects (De Almeida et al. 2010, Evangelista et al. 2011, Bush et al. 2014a, Sandall and Deans 2018, Braun et al. 2019, Young et al. 2019).

The Order Odonata (dragonflies and damselflies) is one of the four insect orders that mainly inhibit aquatic habitats (Tennessen 2019) with at least 6,322 described species known from all around the world (Kalkman et al. 2015, Tennessen 2019, Paulson and Schorr 2020). The large body size, beautiful colors, charismatic behaviors, unique mating system behavior, and many other unique characters allowed Odonata to be of the most popular insect groups (Silsby 2001, May 2019, Tennessen 2019). Both dragonflies and damselflies are considered important food sources of fish, birds, and another vertebrate. Odonata larvae and adults can consume a wide range of invertebrate, including pest species such as mosquitoes and midge larvae (Paulson 2019). They are used with other aquatic insects specially Ephemeroptera, Plecoptera, and Trichoptera in evaluating the ecological assessments of aquatic habitats and water quality indicators (May 2019).

The family Trichoptera occur in almost both lentic and lotic aquatic ecosystems (Wiggins 2014, Morse et al. 2019), even few species can occur in saline water and terrestrial ecosystems (Hering et al. 2009, Morse et al. 2019). Caddisflies larvae have an important role in nutrient cycling of aquatic ecosystem as a result of their diverse feeding strategies (Ross & Wallace 1983, Wiggins 2004). Using silk from salivary glands and the behavior of building various portable cases, nets, and retreats, larvae occur in habitats not fully exploited by other aquatic insects (Wiggins 2014, Morse et al. 2019). Trichopterans are considered of the most important aquatic insect orders as well as a dietary source for insectivorous fish and other animals (Kalaninova et al. 2014). Caddisfly larvae considered the most important shredders in both lentic and lotic ecosystems (Wiggins 2014).

Caddisflies as well as mayflies and stone flies are considered among the most sensitive bio-indicators for aquatic ecosystems and water quality (Holzenthal et al. 2007) and they are widely used in the assessments of aquatic systems (Hering et al. 2009). Hering et al. (2009) found that endemism, feeding guild, and short emergence as the main drivers for caddisfly species sensitivity to climate change.

The focus of this work was on the high elevation aquatic habitats because species therein are vulnerable to rapidly changing environmental conditions (Hering et al. 2009, Bush et al. 2014b). I examined a rare dragonfly species in the southern edge of its range at the high-elevation lentic habitats of Northcentral Colorado and southern Wyoming to provide a habitat suitability model and map for this vulnerable species. I also studied species occurrence patterns and provided distribution maps for lentic caddisfly species occurring in the high-elevation habitats of seven counties in northern Colorado.

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CHAPTER TWO: A SURVEY OF THE HUDSONIAN EMERALD DRAGONFLY IN NORTHCENTRAL COLORADO AND SOUTHERN WYOMING

INTRODUCTION

The insect order Odonata (dragonflies and damselflies) belongs to the Superorder Odonatoptera, which is dated to the early Carboniferous (Kalkman et al. 2015, Tennessen 2019a). Petrulevicius and Gutierrez (2016) described a species from the Guandacol Formation with an age of circa 324-325 million years ago. The family of petaltails, the Petaluridae are still extant today unchanged for the last 100 million years (Ware et al. 2014). The name Odonata is derived from the Greek word "odontos" which means toothed and refers to the large, toothed mandibles of both the larvae and adults. The Odonata are one of the most popular insect groups because of their relatively large size, beautiful colors, observable and charismatic behaviors, and unique copulatory structures with a complex mating system (Carle et al. 2015, May 2019, Tennessen 2019b). The Odonata are a cosmopolitan group with at least 6,322 described species representing 659 genera (Kalkman et al. 2015, van Tol 2019, Tennessen 2019a, Tennessen 2019b, Paulson and Schorr 2020). Members of this order are considered important components of fish, birds, and other vertebrate food chains. Both larvae and adults can consume a wide range of invertebrate and even vertebrate species, including pest species such as mosquitoes and midge larvae (Kalkman et al. 2008, Paulson 2019). The Odonata have been used in evaluating the ecological integrity of specific aquatic habitats and even used as water quality indicators (Oertli et al. 2008, May 2019). Dragonfly conservation is key in enhancing the aesthetic value of aquatic resources and preserving ecosystem function (Packauskas 2005, Kalkman et al. 2008, May 2019).

Dragonflies and damselflies are paleopterous hemimetabolous insects with aquatic eggs, aquatic larvae (nymphs), and terrestrial adults. Adults are easily distinguished by their well-developed large compound eyes, bristle-like antennae, three pairs of spiny legs, large chewing mouthparts, a distinctive labium or lower lip, and bulky thorax with a pair of large narrow wings with copious wing venation (Silsby 2001, Paulson 2019). The larvae of almost all Odonata are aquatic with externally developing wings pads, free legs, a distinct head, thorax, abdomen, and peculiar labium (Silsby 2001, Needham et al. 2014). These larval body characters are specifically distinctive and used for specific identifications (Needham et al. 2014, Paulson 2019, Tennessen 2019b).

Of the 330 species of dragonflies and damselflies recorded from North America (Paulson and Dunckle 2018, Tennessen 2019a), at least 120 species representing seven families have been recorded from Colorado (Prather and Prather 2015). Of these 330 dragonfly North America species, fewer than 20 have available fully described life cycles (Voss & Loewy 2017, Tennessen 2019a, Tennessen 2019b).

The family Corduliidae (the green-eyed skimmers) are of worldwide distribution, comprising 22 genera and 169 species (Kalkman et al. 2008, Kalkman et al. 2015, Tennessen 2019a, Tennessen 2019b). Adults of Corduliidae are usually black or dark brown with areas of metallic green or yellow, and most species have large, emerald-green compound eyes (Needham et al. 2014, Tennessen 2019b). Members of this family include the baskettails, emeralds, river cruisers, sundragons, shadowdragons, and boghaunters (Paulson 2019, Paulson and Dunkle 2018, Tennessen 2019a). The Corduliidae is divided into six subfamilies: the Cordulephyinae, Corduliinae, Gomphomacromiinae, Idionychinae (Asian Emeralds), Idomacromiinae (Central African Emeralds), and the Neophyinae (Silsby, 2001, Paulson and Dunkle 2018, Tennessen 2019a).

The Genus *Somatochlora*

The genus *Somatochlora* Selys, 1871 (the striped emeralds) is the largest genus of the Corduliidae (Packauskas 2005, Paulson and Schorr 2020), with 42 described species occurring across the Northern Hemisphere (Tennessen 2019a). In North America, there are 26 species that range from central Florida to Alaska (Paulson and Dunkle 2012, Packauskas 2005, Paulson 2019, Tennessen 2019a). Adults of *Somatochlora* (Fig. 2.1) are dark with a metallic appearance, brilliant green eyes, partly yellow face, reduced pale markings, and wings usually hyaline (Packauskas 2005, Tennessen 2019a). Species of this genus can be found in different habitats of open forested areas such as ponds and lakes, small streams, fens, seepage springs, bogs, and muskeg pools (Silsby 2001, Packauskas 2005). Larvae are medium-sized corduliids, moderately to very hairy (Packauskas 2005). Mature larvae are large, sometimes commonly encountered in streams but also in lakes as well as seeps and bogs, or springs and streams draining these systems (Paulson 2019, Tennessen 2019a).

The Hudsonian Emerald dragonfly (HED), *Somatochlora hudsonica* (Hagen) in Selys 1871 (Fig. 2.1) is one of the five species of striped emeralds have been recorded from Colorado (Prather & Prather 2015). It is the only Colorado dragonfly listed as threatened by the US Forest Service (Packauskas 2005, Voss & Loewy 2017). Adults of *S. hudsonica* are easily recognized by the brassy green thorax with a single anterior lateral stripe (short, white, diamond shaped); narrow white rings between all abdominal segments; and the 10th ventral segment of abdomen with pale spots at junctions of the cerci (Dunkle 2000, Packauskas 2005, Needham 2014). Larvae are typical of the genus but are moderate to conspicuously hairy (Needham et al. 2014, Tennessen 2019b).

Distribution and Status

The range of the HED extends from Alaska and British Columbia east to Ontario, south to Utah, and the Northern Colorado Rocky Mountains (Paulson and Dunkle 2018). *Somatochlora hudsonica* is reported to be relatively widely distributed in Canada (Walker and Corbet 1978, Dunkle 2000, Macauly & Dunne 2003, Cannings 2019, NatureServe 2020), whereas this species has a relatively limited distribution within the Continental United States, including relatively few currently available records from Colorado (Evans 1988, Evans 1995, Prather and Prather 2015, Paulson 2017, Tennessen 2019, NatureServe 2019 and 2021), Wyoming (Molnar and Lavigne 1979, NatureServe 2019 &2 021), Montana (Kohler and Currier 2009, NatureServe 2020), and Utah (Myrup and Baumann 2016). The occurrence of the HED in Colorado is relatively localized with documented records from 22 sites in Boulder (15 sites), Gilpin (2 sites), Larimer (4 sites), and Park (1 site) Counties (Appendix 1, Packuaskas 2005, Prather and Prather 2015, Voss and Loewy 2017, Abbott 2017, Odonata Central 2019 & 2021). The HED has been occasionally collected at eight sites in five counties in Wyoming, Albany (3 sites), Carbon (2 sites), Johnson (1 site), Sublette (1 site), and Teton (1 site) Counties (Packuaskas 2005, Molnar and Lavigne 1979, Odonata Central 2019 & 2021). Relatively few specimens of this species are deposited in museums and other collections, with few additional documented presence records, which seems to indicate that this species may occur as relatively small populations at higher elevations in Colorado and Wyoming (Packuaskas 2005).

The HED has a global rank of G5 ("secure; at very low or no risk of extirpation in the jurisdiction due to its extensive range, abundant populations, or occurrences, with little to no concern from declines or threats (NatureServe 2020, Fig. 2.2). The NatureServe (2020, Fig. 2.2) ranked the species S3 ("vulnerable with a high risk of extirpation with relatively few occurrences, steep decline, severe threats, or other factors") in Montana and Wyoming. In Utah, it has no status rank according to the NatureServe (NatureServe 2020, Fig. 2.2), however, Myrup and Baumann (2016) ranked it as S2/S3 (sensitive-vulnerable). The Colorado Natural Heritage Program) ranked the HED as an S2/S3 in the state, maybe because of few occurrences (less than 20), and placed it on the watchlist (Packuaskas 2005). It was ranked as S1 ("critically imperiled, at a high risk of extirpation in the jurisdiction due to very restricted range, very few populations or occurrences, very steep declines, severe threats, or other factors") in Colorado by the Online Encyclopedia of Life, NatureServe (Fig. 2.2, NatureServe 2020.), whereas the NatureServe ranked it as imperiled (S2) in 2019 (NatureServe 2019).

Habitat

Larvae of the HED have been reported to occur in deep, sedge bordered ponds and lakes, at boggy edges, in sedge marshes, in ponds with lake inlets, in boggy slow streams, at edges of woodland streams, ditches, and sloughs (Dunkle 2000, Packauskas 2005, Prather and Prather 2015, Voss and Loewy 2017). It has been reported that larvae development occurs in lentic habitats where summer water temperatures range from 16˚ to 20˚C (Packauskas 2005). Catling and Brownell (2000) characterized the larval habitat of the HED in Ontario as that of slow streams and boggy ponds. In Colorado and surrounding states, the HED typically inhabits lentic habitats above 2,500m (Packauskas 2005, Voss and Loewy 2017). Prather and Prather (2015) stated that: this species is found in relatively large numbers at edges of certain lentic habitats in northern mountains above 2,700m. Available records of the species indicated that the HED is found at an altitude above 2,000m. Miller and Gustfson (1996) also noted *S. hudsonica* adults fly along grassy margins of mountain lakes and ponds from 3 July to 4 August in Montana. Voss and Loewy (2017) documented the occurrence of *S. hudsonica* in Boulder County Parks and Open Space properties, Caribou Open Space, Duck Lake, and Barron land parcels, and assumed that HED is quite rare as indicated by exuvial and adult field surveys. Voss and Loewy (2017) concluded that the rareness of the species in Boulder County was related to the county lying at the southern-most edge of the known distribution of the species.

Voss and Loewy (2017) collected in Boulder County two *S. hudsonica* larval exuviae from two different sites; rocky-bottomed, high-altitude precipitation fed kettle wetland in the Barron parcel and a lower-altitude series of mucky ponds along Delonde Creek. Four adult specimens of the HED were collected from the North Fork of the Little Laramie River on September 4, 1978, by the late Robert Lavigne (formally of the University of Wyoming), and he mentioned: "a plenty of them were at that site, and any dragonflies collector knows that it is hard to collect four specimens from a single site at the same time" (Packauskas 2005).

The aquatic habitat requirements for the phylogenetically related Hines Emerald, *S. hineana* Williamson, 1931, a dragonfly listed as federally endangered (Packauskas 2005), have been characterized by Cashatt and Voget (2001) as "having a very narrow and some unifying features, which includes calcareous water from intermittent seeps; shallow small channels; shallow, organic muck over dolomitic bedrock." Many of these habitats were dominated by graminoid plants such as tussock sedge (*Carex stricta* Lam, U.S. Fish and Wildlife Service 2001), sweet flag (*Acorus calamus* L., Cashatt and Voget 2001), or cattail (*Typha* spp., U.S. Fish and Wildlife Service 2001).

Biology

Little is known about the life history of the HED, including egg overwintering and the duration of the larval stage (Packauskas 2005, Voss and Loewy 2017). Walker (1925) estimated that the life history is considered to be semivoltine, a two-year cycle, overwintering as eggs. The adults have been reported to live from 1.5-2.0 months. Their flight season in Canada and the United States range from late May to late August (Paulson 2019, Voss and Loewy 2017), depending on altitude, although there are records as late as September (Packauskas 2005, Odonata Central 2020).

No detailed life history information is available for the HED. However, there is some available information for the related species, the Hine's Emerald (Packauskas 2005). Vogt and Cashatt (1994) described the copulatory behavior of the Hine's Emerald. Tandem pairs fly toward shrubs or nearby trees. They also noted that these peripheral shrubs and trees are important mating areas for this dragonfly. Males of many species guard females or fly in tandem during oviposition. Females fly over water surface or aquatic mosses, striking the water surface with the end of her abdomen in short intervals releasing a large number of eggs (Packauskas 2005, Tennessen 2019a). Oviposition also takes place over soft muck or shallow water (Vogt and Cashatt 2001). The number of eggs laid by *S. hudsonica* is unknown. During her adult lifetime, a Hine's Emerald female laid up to 500 eggs (U.S. Fish and Wildlife Service 2001). Eggs of the Fine-lined Emerald, S. *filosa* Hagen, 1971, hatched in 20 to 30 days (Dunkle 1977).

Larval development of the HED usually takes place in ponds or lakes with good water quality, but the number of larval instars is still unknown (U.S. Fish and Wildlife Service 2001, Packauskas 2005, Voss and Loewy 2017). Corbett (1999) suggested that the *Somatochlora* has 13 to 14 larval instars. Tennessen (2017) noted that the total number of instars varied between species of the genus, and the common number is 11 to 13 instars. The total number of larval molts appears to vary within species and between larvae hatched from egg mass from a single female. It is impossible to determine the number of larval molts and the exact stage of a field-collected larvae (Tennessen 2017). The duration of larval stages of this genus occurs across at least two seasons (years), and their entire life cycle may take three seasons (Walker 1925, U.S. Fish and Wildlife Service 2015). Adult life span of this species is relatively short (Packauskas 2005). The life span of the related Hine's Emerald dragonfly is 14 days to six weeks (Packauskas 2005, U.S. Fish and Wildlife Service 2015). Uncertainty of life history data is especially relevant when evaluating the life cycle of HED (Packauskas 2005, Voss and Loewy 2017).

Potential Threats

Habitat disturbance and pollution impacts are substantial threats to the HED. Voss and Loewy (2017) noted that little is known about the species tolerance to disturbances. At this time, specific experiments have not been conducted to identify effects of possible threats to the *S. hudsonica*, but threats to high-elevation freshwater lentic ecosystems of its Colorado range are relatively well-documented (Bahls 1992). These include, but are not limited to, increased predation by introduced salmonids, deforestation, sedimentation, air pollution and deposition, dam construction, and organic enrichment (Packauskas 2005, Voss and Loewy 2017, Paulson and Dunkle 2018). Water acidification also has negative effects on Odonata (Packuaskas 2005, Tennessen 2019a). Mining, a frequent disturbance in Colorado (Sims et al. 2013), often produces compounds that increase water acidity when mixed with water (Bradt and Berg. 1987).

Predicted threats to the HED habitat could include those that directly impact water quality, including atmospheric depositions of both carbon and acid (Baron et al. 2021), sedimentation, mining, pesticide or piscicides use, vegetation loss, and salmonid stocking (Packauskas 2005, Voss and Loewy 2017). Surrounding trees are a major component of the aquatic habitat utilized by the HED, serving as important mating sites (Walker 1925, Cashatt and Vogt 2001). Additionally, trees and other vegetation serve as foraging sites for adults, where they perch and feed (Packauskas 2005, Voss and Loewy 2017, Tennessen 2019b). Predation is considered the main cause of both larval and adult mortality (Cashatt and Vogt 2001, Paulson 2019). Fish are the main predator of emerging adults and larvae (Packauskas 2005, Paulson 2019). Salmonid presence might have a negative effect on S. *hudsonica* breeding habitat as dragonfly larvae often make up a substantial portion of salmonid fish diets (Bahls 1992, Paulson 2019).

Species Distribution Modelling

A variety of habitat suitability models are used in predicting potential species distributions (Guisan & Zimmermann 2000, Elith et al. 2006). Species Distribution Models (SDM) use climate, biological, and topographic data to define species distribution ranges and potential distribution spatially (Phillips and Dudik 2008, Peterson et al. 2012, Young et al. 2019). Species Distribution Models have been successfully used for wildlife species (Thorn et al. 2009, Kalboussi and Achour 2018), invasive species (Kumar et al. 2009), plants (Kumar & Stohlgren 2009, Kumar 2012), and insects (De Almeida et al. 2010, Evangelista et al. 2011, Bush et al. 2014a, Sandall and Deans 2018, Braun et al. 2019, Young et al. 2019). Few models have used small sample sizes to predict the potential distribution of rare species and aid in conservation planning (Pearson et al. 2007, Thorn et al. 2009). Species Distribution Models performance relies on model parameters, which define species response to each environmental variable, affecting model performance and discriminatory ability, such as regularization (parameter on Maxent setting affects how the output distribution is focused or closely fitted) and feature classes (Elith et al. 2011, Merow et al. 2013). Maxent (Maximum entropy) is a machine learning program that uses species presence data and environmental variables to predict potentially suitable habitats for the species (Philips et al. 2006, 2008). Maxent uses presence-only data which is important in modelling rare and cryptic species because true absences are difficult or often impossible to verify (Philips et al. 2006, Pearson et al. 2007). Maxent also performs well with a small sample size (Pearson et al. 2007, Kumar et al. 2009, Kumar & Stohlgren 2009, Young et al. 2011, Zheng et al. 2016), and is a more robust approach compared to other methods (Elith & Graham 2009). Occurrence records and distribution data of rare and threatened species are usually cluster and are sparse (Engler 2004). Kumar and Stohlgren (2009) used a relatively small number of occurrence records (only 11 records) in predicting the potential suitable habitat for *Canacomyrica monticola*, Guillaumin 1941, a threatened and endangered tree species in New Caledonia.

STUDY OBJECTIVES

My study was designed to determine the relative occurrence and distribution of the HED restricted to high-elevation lentic habitats in the Arapaho and Roosevelt National Forest (ARNF) and Medicine Bow & Routt National Forest (MBRNF) in Northcentral Colorado and southern Wyoming. This includes providing all available known occurrence records and new occurrences of the HED in the two national forests. Distribution patterns, lake occupancy, and other relevant ecological, biological, and behavioral information will be provided. This information will be used by administrators of the two national forests to implement management plans to protect this dragonfly.

The specific objectives of my research were:

1. Evaluate the conservation status of the HED in the ARNF and MBRNF in Northcentral Colorado and southern Wyoming based on published, unpublished, and new collections from my study.
2. Develop a probabilistic species distribution model (Maxent) for the HED to predict potentially occupied sites for future surveys and produce habitat suitability map products (i.e., geospatial data layers) for *S. hudsonica* in the ARNF and MBRNF in Colorado and Wyoming.

3. Identify the most important environmental variables that affect the spatial range of the Hudsonian Emerald**.**

MATERIALS AND METHODS

Study Area

My study included three seasons of sampling of montane and alpine lentic habitats (following Pennak's 1969) for the HED along the southern most known range of the species. Collections were made within the ARNF and MBRNF (Fig. 2.3). The ARNF was established in 1908 by President Theodore Roosevelt, includes 292,889 hectares (723,744 acres) of alpine, montane, and lower montane forest, and is located in portions of Boulder, Clear Creek, Gilpin, Grand, Jackson, and Larimer Counties of Colorado. The ARNF includes the high Rockies and river valleys (Bailey 2016), and straddles the Continental Divide, and includes the headwaters of the Colorado River and the South Platte River (US Forest Service 2019). The MBRNF covers nearly 1,173,588 hectares (2.9 million acres) in central Wyoming and Northcentral Colorado (US Forest Service 2019). The two forests lie within the Northern Parks and Ranges, and the North Central Highlands and Rocky Mountain Sections of the Temperate Steppe Regime of Baileys Ecoregions (Bailey 2016), from an elevation range from 1,676 to 3,944m (US Forest Service 2019). The MBRNF was established in 1902 in southeastern Wyoming, extending across portions of Albany, Carbon, Converse, Natrona, and Platte Counties (USDA 2011). The Routt National Forest was established by President Theodore Roosevelt in 1905; it is located in Grand, Jackson, Moffat, Rio Blanco, and Routt Counties in northern Colorado (USDA 2011).

The first sampling season was from June to September 2019 in the ARNF, Northcentral Colorado (Fig. 2.3). The second and third sampling seasons were from June to September 2020, and 2021 included accessible montane and alpine ponds and lakes sites in both of the ARNF and

MBRNF in Northcentral Colorado and southern Wyoming, mainly in Albany and Carbon counties (Fig. 2.3).

The Hudsonian Emerald Dragonfly Occurrence Records

All *S. hudsonica* records in Colorado and Wyoming were compiled from peer-review literature (Molnar and Lavigne 1979, Packauskas 2005, Voss and Loewy 2017); a collection of the C.P. Gillette Museum of Arthropod Diversity, Colorado State University; from available online databases (Odonata Central 2019 & 2021); and from the iNaturalist website database (iNaturalist 2020).

Georeferenced occurrence localities (Figs. 2.4 & 2.5) were compiled from sampling surveys of the high-elevation lakes of ARNF and MBRNF during the adult emergence and flight period (i.e., June to September) during 2019, 2020, and 2021. Odonata adults were collected using aerial nets along margins of lentic sites, and larval were collected using D-frame kick net (1-mm mesh) from lake shorelines at each site visited during the three sampling seasons (2019-2021). Total dissolved solids (TDS), water temperature, conductivity, and pH were measured on-site during each site visit using a HACH portable device (Table 2.1). Logistic regression analysis was used to determine the important water parameters for explaining the presence/absence of the HED. Statistical analysis was carried out with SPSS V 27.0 (IPM corp. 2020). Visual observations were made to record all mating pairs, oviposition, behavior, and adults activity. Larval exuvia of Anisoptera were collected to check for the HED. Coordinate data were recorded for all new collection sites directly using Topo Maps version 1.16 for iPhone. I used ArcGIS 10.7.1 to plot coordinate data and map measurements, measure geographic and catchment parameters. Watershed (lake) boundaries and physio-geographic boundaries were obtained from the USGS National Hydrology Dataset (U.S. Geological Survey 2019).

Species Distribution Modelling

I used a probabilistic species distribution modelling approach to define suitable habitat areas and locate new occurrence localities (Verdone and Kondratieff 2018, Young et al. 2019) for the HED in the ARNF and the MBRNF. Geospatial locations of all previously available Colorado and Wyoming *S. hudsonica* occurrence records and summer sampling of 2019 records were used to predict potential new occurrences of the species using maximum entropy modelling, Maxent software (Phillips and Dudik 2008, Young et al. 2019), to identify potential habitat for future sampling in ARNF and MBRNF and determine the likelihood for presence or absence of the larva, larval exuvia, or adults.

MaxEnt software version 3.4.4 (Philips et al. 2006 & 2008) was used to develop suitable habitat predictions for *S. hudsonica* in the high-elevation lakes of ARNF and MBRNF in Northcentral Colorado and southern Wyoming (Phillips & Dudik 2008, Baldwin 2009, Young et al. 2019). I used 21 environmental variables (Table 2.2) from published climate and vegetation data sources (NLCD 2016, Worldclim.org, Fick and Hijmans 2017).

Climate data (Table 2.2) were obtained from Worldclim.org (Fick and Hijmans 2017), which provides average monthly climate data for minimum, mean, and maximum temperatures and for precipitation from 1970-2000 in 30 arc-seconds (~1 km^2) resolution. These 19 bioclimatic variables provide information about annual conditions, seasonal mean climate conditions, and intra-year seasonality that relate to species physiology (O'Donnel and Ignizio 2012). Elevation data were obtained as digital elevation model (DEM) grids data, including 1 arc-second (~30 m^2) from the USGS National Elevation Dataset (Gesch et al. 2002). Vegetation data were obtained from the Multi-Resolution Land Characteristics (MRLC) Consortium National Land Cover Database 2016 (NLCD 2016). This database provides a 16-class land cover classification scheme and percent canopy cover at a spatial resolution of 30 arc-seconds based on a decision-tree classification of 2016 Landsat satellite data (Yang et al. 2018).

All environmental variables were processed using ArcGIS ArcMap 10.7.1 (Redlands, C. E. S. R. I. (2011). Variables were projected to North America 1983 (NAD 1983) projected coordinate system and clipped to the study area boundaries, using the extract by mask tool (Spatial Analyst: Extraction). Output coordinate systems (Output Coordinates) were set to NAD 1983 (geographic coordinate system). Extent (Processing Extent) and snap raster were set to the bio_1 file (the first layer to be processed). Cell size (Raster Analysis) was set to (approximately 1 km^2) as specified by the bio_1 file. All variables were subsequently converted to ASCII file type using the raster to ASCII tool (Conversion Tools: From Raster) to be loaded to the Maxent Software (Phillips et al. 2006). Overall, a total of 34 unique locality records of the target species, 26 from Colorado and eight from Wyoming, were used in model building (2021 sampling season records were not used in model building) after removing duplicate records. Some records obtained from Odonata Central were removed from the model because the exact georeferenced data was lacking.

To build the best SDM model, I applied a set of selection procedures ('tuning') prior the main analysis to obtain the best fit in model discriminatory ability (Merow et al. 2013), and I used environmental variables used in previous Odonata modelling studies (Bush et al. 2014a, Sandall and Deans 2018). In total, I ran 360 different MaxEnt models using four different strategies with a set of selection procedures (Table 2.3). Each strategy model was initiated using the default settings following Young et al. (2011). Maxent settings were changed in each strategy model to select the best fits. These changes include the betamultiplier (regularization value: 0.25,0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, and 5) and replicate type, which was used once as default (sub-sample) or changed to cross-validation with each regularization value to reduce overfitting (the difference between $AUC_{training}$ and AUC_{test} <0.05) and improve extrapolation (Elith et al. 2011). MaxEnt outputs included a logistic probability map which shows potential habitat as a probability between 0–1, and a Multivariate Environmental Similarity Surface (MESS) map to identify novel regions outside the environmental range of the model training data (Elith et al. 2011).

In the first strategy, the 19 WorldClim variables (Fick and Hijmans 2017) with land cover and minimum distance from lakeshore to tree cover were used to run the model. Pearson correlation analysis (SPSS software version 24, IPM Corp. 2016) was used to test for multicollinearity since it could affect model efficiency and result in over-fitting (Merow et al. 2013, Young et al. 2019). One of each pair of highly correlated variables ($|r| > 0.7$) was removed (stepwise removal of variables). Variables were retained based on the percentage of deviance explained, ecological relevance, and expert opinion. Additionally, direct variables were given preference over indirect variables. The selection process retained up to seven variables: Annual mean temperature (Bio_1), temperature seasonality (Bio_4), mean temperature of wettest quarter (Bio_8), precipitation seasonality (Bio_15), precipitation of driest quarter (Bio_17), precipitation of wettest warmest quarter (Bio_18), and land cover, for building the MaxEnt model using this strategy (Table 2.3).

In the second strategy, stepwise variable removal was used again, removing the variable contributing the, and running the model again until the best model fit was obtained (the highest AUC and the smallest value of the ($AUC_{training}$ - AUC_{test}). The best fit model from this strategy was obtained from using seven environmental variables, namely: Annual mean temperature (Bio_1), temperature seasonality (Bio_4), mean temperature of warmest quarter (Bio_10), precipitation seasonality (Bio_15), precipitation of driest quarter (Bio_17), precipitation of wettest warmest quarter (Bio_18), and precipitation of coldest quarter (Bio_19, Table 2.3).

In the third strategy, six environmental variables were used; Annual mean temperature (Bio_1), temperature seasonality (Bio_4), minimum temperature of coldest month (Bio_6), precipitation seasonality (Bio_15), precipitation of wettest quarter (Bio_16), and precipitation of driest quarter (Bio_17) following Bush et al. (2014a) with different tunning parameters resulting in an AUC of 0.935 (Table 2.3).

The fourth strategy was done following Sandall and Deans (2018) using eight environmental variables: Annual mean temperature (Bio_1), temperature seasonality (Bio_4), maximum temperature of warmest month (Bio_5), mean temperature of wettest quarter (Bio_8), mean temperature of warmest quarter (Bio_10), annual precipitation (Bio_12), precipitation of wettest warmest quarter (Bio_18), and precipitation of coldest quarter (Bio_19), and LandCover (Table 2.3).

The final models of all the four strategies were built following Young et al. (2011) with 15 replicates, a standard 80/20 split for training and testing data, 1.5 regularization multipliers, 5000 iterations, and 10 percentile training presence. All outputs were obtained in logistic format.

The Receiver Operating Characteristic, Area Under the Curve (AUC) and the difference between the training AUC and the value of test AUC ($AUC_{training}$ - AUC_{test}), and the sensitivity and specificity values were used to evaluate the different model strategies (Radosavljevic and Anderson 2014). AUC give values ranging from 0-1, larger values indicating better models with values >0.5 (Philips 2006). If the AUC value <0.5, the model is not better than random, indicating it does not have the ability to predict the suitable habitats for the species under study (Philips 2006, Young et al. 2011).

Predicted Suitable Habitat of the Hudsonian Emerald

The Maxent outputs include a logistic habitat suitability map; this map was changed to raster using Conversion Tools (to raster) ArcGIS ArcMap 10.7.1 (ESRI). I used the average logistic threshold of the maximum training sensitivity + specificity calculated by Maxent for the 15 model replicates (0.249) to reclassify the potential suitable habitat for HED (Young et al. 2011). The plotted map has a range from 0 to 1, where 0 representing unsuitable habitat and 1 representing high suitability. These values were reclassified using the tool (reclass) ArcGIS ArcMap 10.7.1 (ESRI) into four suitability classes: 0.75-1.0 represented high suitable habitat, 0.50-0.75 indicated moderate suitability, 0.25-0.50 represented low suitability, and 0-0.25 was considered unsuitable habitat. The mean of the maximum training sensitivity plus specificity threshold (0.249) was used to convert continuous model result of the potential suitable habitat of HED to binary (Young et al. 2011).

RESULTS

All sampled lakes were high-elevation (2,500 - 3,910m). Most of these lakes have a small surface area of 0.2 - 16.0 ha. Fish were present in most of the lakes and mostly absent at lakes above the tree line. Water parameters sampled in the two states varied considerably in physical and chemical characters (Table 2.1).

The Chi-square value of binary logistic regression model analysis for water parameter data of the sampled lakes (SPSS V 27, IPM corp. 2020) was statistically significant (Tables 2.4 & 2.5), which indicated a good model fit. The model has an overall accuracy of 85.9% in predicting the presence or absences of the HED occurrence from water quality parameters.

The Hudsonian Emerald dragonfly Occurrence Records

A total of 100 occurrence records from 41 unique high-elevation lakes (32 in Colorado and 9 in Wyoming) of the HED were documented in this study. In addition, six previous records were deleted since they were georeferenced only to county center without any specific locality data and where no nearby water bodies were apparent, one in Colorado and five in Wyoming (Appendix 1, Figs. 2.6 & 2.7, Table 2.6). Eighty-two *S. hudsonica* occurrence records were reported from Colorado and 18 records from Wyoming (Appendix 1). The 82 Colorado occurrence records were reported from Boulder (44 records), Gilpin (8), Larimer (29), and Park (1) Counties in Northcentral Colorado. More than a fourth of the records being reported herein (22 records) of the 81 Colorado records were collected during my three sampling seasons (2019-2021). Voucher specimens of these records are deposited in the C.P. Gillette Museum of Arthropod Diversity, Colorado State University (Appendix 1 and Table 2.6). Odonata Central website (2019 & 2021) previously listed seven records for *S. hudsonica* from Colorado. One of these records is deposited in the C.P. Gillette Museum of Arthropod Diversity. Other Odonata Central records from Colorado include Boulder County: Rainbow Lake, P. Prather, 10-VIII-2018; Rainbow Lake, Prather P., 7-VIII-2018; Unknown location, A., and J. Cooper, 6-VIII-2008; Larimer County; Unknown location, A. and J. Cooper, J. 17-VII-2009; Lost Lake, near Chambers Lake, H. Hooper, 3-VIII-2019; Cub Lake Trail, Rocky Mountain National Park, D. Czaplak, 4-VII-2013 (Odonata Central 2019 & 2021). The remaining records were obtained from literature (Packuaskas 2005, Prather and Prather 2015, Voss & Loewy 2017) and two records from the iNaturalist websites (2019). One record from Larimer County was not included in building the model since it was collected from a low elevation site, and this specimen was found dead floating in the lake; it may have dispersed from a higher elevation site.

Eighteen *S. hudsonica* occurrence records from nine specific localities in five counties (Figs. 2.5 & 2.7, Appendix 1) were reported in Wyoming (Albany (13 records), Carbon (2), Johnson (1), Sublette (1), and Teton (1) Counties). Of these 18 occurrence records in Wyoming, two records are deposited in the C.P. Gillette Museum of Arthropod Diversity (Albany County, Hanging Lake, B.C. Kondratieff & M. Al Mousa, 21-VII-2020, Albany County, Hanging Lake, M. Al Mousa, 18-VII-2021, Table 2.6). The other records were obtained from literature (Molnar and Lavigne 1979, Packuaskas 2005) and from the Odonata Central website (2019 & 2021).

During my field survey of the montane and alpine ponds and lakes in the ARNF and MBRNF in the summer of 2019, 2020, and 2021, I accomplished 213 sampling events (Colorado 162 and Wyoming 51 sampling events). At 60 sampling events in the summer of 2019 (Table 2.1), *S. hudsonica* was collected during 11 occasions at nine sites in Boulder, Gilpin, and Larimer counties. Fifty *S. hudsonica* adult specimens were collected from 11 montane and alpine lakes in the ARNF in the summer of 2019 (Table 2.6, Appendices 1 & 2), including a photograph taken on 31 July 2019 of a male at Lost Lake, off Rawah Trail, Larimer County. The presence of the HED was reconfirmed at five sites: three in Boulder County (Rainbow Lakes (lower and middle lakes) and Red Rock Lake), and two in Larimer County (Twin Lakes, and Lost Lake). *Somatochlora hudsonica* was recorded for the first time at five new sites: two in Gilpin County at Forest Lakes (lower and middle lakes) and three new records in Larimer County from Laramie Lake, Trap Lake, and Lost Lake in Rawah Wilderness (Table 2.6, Appendices 1 & 2). One hundred and two sampling events were made in the summer of 2020 (Table 2.1); 58 of these events were taken at the high-elevation ponds and lakes of ARNF and RNF in northcentral Colorado and 44 events in the high-altitude ponds and lakes of MBN in southern Wyoming. Seven specimens of the HED were collected in 2020 (Table 2.6, Appendix 2). I recorded the HED for the first time at Hanging Lake, Albany County, Wyoming (Table 2.6, Appendix 2). The presence of the HED was reconfirmed at two additional lakes in Colorado, namely, Lost Lake (Larimer County) and Red Rock Lake (Boulder County). In the summer of 2021, I conducted 51 sampling occasions in both of the two national forests to validate the Maxent model, confirm the previous presence records and check the short-term effect of the Cameron Peak Fire (Colorado Encyclopedia, https://coloradoencyclopedia.org/article/wildfire-colorado) on the HED (Table 1). Thirty-one specimens were collected in the summer of 2021 (Appendices 1 & 2, Table 2.6). I collected the species for the first time from four new localities in Colorado (Table 2.6): Two locations in Boulder County (pond, west of Long Lake and the upper lake of Rainbow Lakes), one lake in Gilpin County (Forest Lakes, the upper lake), and one lake in Larimer County (Zimmerman Lake). The presence of this species was reconfirmed in six sites, five lakes in Colorado (3 in Boulder County and 2 in Gilpin County), and one lake in Wyoming (Hanging Lake, Albany County). No HED adult specimens were collected or observed at the burned area of the Cameron Peak Fire, although it was recorded from the area in 2019 and 2020 sampling seasons at Lost Lake, Laramie Lake, Trap Lake, and Twins Lakes (Appendices 1 & 2, Table 2.6).

The first collection of the HED was in mid-July. Snowpack in 2019 season was especially high (https://www.weather.gov/bou/co_snowpack), resulting in difficult access and partial ice cover until early July at many sites. Water temperatures were low at most of the sampled lakes, averaging 15°C in the three sampling seasons, 2019, 2020, and 2021. In total, 88 specimens of the HED were collected in the three-seasons sampling study, 78 males and ten females. The females of the HED were observed several times hovering near mossy lake edges striking their abdomen on water surface for two to three seconds, laying eggs.

Despite the extensive efforts to sample larvae and larval exuvia during the three sampling seasons, no larvae nor larval exuvia were collected. In the three seasons, no larvae or larval exuvia of the Corduliidae was collected.

Species Distribution Modelling

The ROC values for the MaxEnt models of the four different strategies showed an AUC value of 0.93-0.95, indicating that the prediction accuracy of these models was excellent, and each model strategy was reliable in defining the suitable habitats of the HED in Northcentral Colorado and southern Wyoming. Strategies number one (stepwise removal of highly correlated variables) and number four (following Sandall and Dean 2018) represented the best model fit with the highest AUC values of 0.951, and 0.95 respectively (Fig. 2.3). Strategy number one gave the lowest value of change of AUC ($AUC_{training}$ - AUC_{test}= 0.004) and was used to create the final habitat suitability maps and to determine the most important environmental variables that affect the HED distribution. Seven variables were used to initiate this model: Annual mean temperature, temperature seasonality mean temperature of wettest quarter, precipitation seasonality, precipitation of driest quarter, precipitation of warmest quarter, and LandCover (Tables 2.7 & 2.8).

O'Donnell and Iginizio (2012) define temperature seasonality: "the amount of temperature variation over a given year (or averaged years) based on the standard deviation (variation) of monthly temperature averages." Precipitation seasonality is a measure of the variation in monthly precipitation totals over the course of the year. This index is the ratio of the standard deviation of the monthly total precipitation to the mean monthly total precipitation (also known as the coefficient of variation) and is expressed as a percentage (O'Donnell and Iginizio 2012).

The key environmental factors that affect the distribution of the HED were determined according to the contribution for each variable to the modelling process and using the Jackknife Test (Figs. 2.6 & 2.7, Tables 2.7 & 2.8). Five variables, all of which are temperature and precipitation variables (temperature seasonality, mean temperature of wettest quarter, precipitation seasonality, precipitation of warmest quarter, and precipitation of driest quarter) contributed: 91% to the model.

Temperature seasonality (Bio_4) has the highest contribution percent of 28.7% with an optimum value of 680-730 according to Maxent response curves (Fig. 2.8, Table 2.8); mean temperature of wettest quarter (Bio_8) has a contribution of 17.9% with a suitable range of -7-17˚C, and optimum range of 0-13˚C; precipitation of warmest quarter (Bio_18) 15.8% and a suitable range of 135-195mm; precipitation of driest quarter (Bio_17) contributed 15.1% with a suitable range of 70-144mm; and precipitation seasonality (Bio_15) has a contribution of 13.5% and a suitable range of 16-32%. Tree canopy cover (LC) has a contribution of 7.3% with potential suitable habitat of at least 12% of tree canopy cover; and Annual mean temperature has a contribution value of 1.7% with suitable range of 0-5˚C (Table 2.8). The Pearson correlation coefficient values for the final seven key environmental variables were less than 0.7, which indicates low collinearity.

Predicted Suitable Habitat of the Hudsonian Emerald

The Maxent plotted a logistic habitat suitability map for the HED with a range of values from 0 to 1, where 0 representing unsuitable habitat and 1 representing high suitability. I used the average of value of the logistic threshold of the maximum training sensitivity plus specificity threshold (Young et al. 2011) calculated by Maxent for the 15 model replicates (0.249) to reclassify the potential suitable habitat for HED. The potential suitable habitat was reclassified using the tool (reclass) ArcGIS ArcMap 10.7.1 (ESRI) into four classes (Fig. 2.9): 0.75-1.0 represented high suitable habitat, 0.50-0.75 indicated moderate suitability, 0.25-0.50 represented low suitability, and 0-0.25 was considered unsuitable habitat.

The potential suitable distribution of *S. hudsonica* according to the Maxent results is shown in Fig. 2.9. The suitable area of this species in the study area is mainly located in the Snowy Range area of the Medicine Bow National Forest, in the southeastern parts of Carbon County, and southwestern Albany County in Wyoming. The suitable habitat of the species in northern Colorado is located in the high-elevation lentic habitats of The ARNF and Rocky Mountain National Park in Larimer, Boulder, Gilpin, and Clear Creek County.

DISCUSSION

The Hudsonian Emerald dragonfly Occurrence Records

The 25 records of HED during 2019-2021 increased the total number of verified available records to 100 for its known Colorado and Wyoming distribution. I documented the presence of the HED for the first time from 11 new lakes (10 in Colorado and one in Wyoming) in Northcentral Colorado and southern Wyoming (Appendix 1, Table 2.6). The 11 new locality records increased the number of lakes where HED was recorded in the two states: Colorado records to 32 occurrence records, and Wyoming records to 9 records.

Almost all the adults of HED were collected along mossy or sedge-rush lake margins. Miller and Gustfson (1996) observed the HED flying along high-elevation lakes grassy margins. Populations of HED are apparently associated with relatively deeper lakes and ponds, often with well-developed submerged and emergent macrophytes, especially Nuphar (Lily pond). Lake substrates ranged from muddy bottoms to mud and rock. Apparently, shallow lakes that freeze to the bottom are not used by this species in its Colorado and Wyoming distribution. Many of these aquatic habitats were dominated by graminoid plants such as tussock sedge, sweet flag, or cattail (*Typha* spp.). The habitats of the related Hine's Emerald were dominated of these graminoid plants (Cashatt and Voget 2001, U.S. Fish and Wildlife Service 2001). All of these lakes were surrounded by trees, mainly ponderosa pine (*Pinus ponderosa*) and douglas fir (*Psuedostsuga menziesii*). The minimum distance to tree cover was less than 100m in all of these lakes. These observations agreed with Packauskas (2005), and Voss and Lowey (2017) descriptions of HED habitat.

In my three-season sampling study, 78 males and ten females were collected (males represented almost 89% of collected specimens). Males of HED were usually observed hovering above lake edges, searching for mates. Adults HED were observed flying near surrounding trees 100-500m from the lakes. Females were observed flying near water edges striking the water surface with the end of her abdomen in short intervals to lay their eggs. My observations agreed with Packauskas's (2005) and Tennessen's (2019a) previous observations. Adult HED were observed flying near lake edges from mid-July to late August, adults life span of this species is relatively short (Packauskas 2005). The flight season of HED in Canada and the United States range from late May to late August (Paulson 2019, Voss and Loewy 2017). Tandem pairs were observed meeting at lake edges then fly to nearby trees. Trees are important perching and mating sites for HED (Walker 1925, Cashatt and Vogt 2001, Packauskas 2005, Tennessen 2019b). Vogt and Cashatt (1994) documented the same observations about the Hine's Emerald copulatory behavior.

During these three sampling seasons, the 2020 summer season had the lowest records and the fewest collected specimens as compared to 2019 and 2021 seasons with only four records, two of these records were from the same locality (Red Rock Lake, Boulder County, Table 2.6). One reason for this could be the HED larval development is semivoltine, taking at least two years, and perhaps emerging cohorts were lower in 2020. Both Walker (1925) and U.S. Fish and Wildlife Service (2015) have reported a two-year life cycle for the related Hines Emerald. Summer precipitation in the year 2020 was low compared to the years 2019 and 2021, this also could explain the lower number of records in this season, since precipitation of the warmest quarter is a key variable in HED occurrence.

Species Distribution Modelling

I have quantified the environmental niche of the HED across its southern-most North American distribution range in northcentral Colorado and southern Wyoming. Results of the three sampling seasons and this model fit the known distribution of this species in this area of Colorado and Wyoming (Molnar and Lavigne 1979, Packauskas 2005, Odonata Central website 2019 & 2021, iNaturalist websites 2021).

Environmental variables contribution and the Jackknife analysis (Fig. 2.7, Table 2.8) indicated that temperature seasonality (Bio_4) and mean temperature of the wettest quarter (BIO_8) apparently are the most important variables predicting the occurrence of HED, with a contribution of 28.7 % and 17.9%, respectively. Table 2.3 also indicated that temperature seasonality was the variable with the highest contribution of the final models in the four different strategies used in this study. Based on the response curves plotted by the Maxent, temperature seasonality higher than 760 is not suitable for HED. Annual mean temperature lower than 0˚C and more than 5˚C will apparently decrease presence probability of this dragonfly species (Fig. 2.8, Table 2.8), which also demonstrated that the optimal temperature for the occurrence of HED was low. The mean water temperature of the lakes where HED was recorded in 2019-2021 was 16.8˚C (Table 2.1). Habitats of mean temperature of the wettest quarter above 17˚C are not suitable for the HED, Packauskas (2005) also reported that HED larval development occurs in lentic habitats with summer temperature range of 16-20˚C. Sandall and Deans (2018) found that the distribution of the Nearctic narrow-wing damselflies (Pond Damsels) was influenced by environmental variables representing air temperature. The importance of air temperature in predicting the suitable habitat of this ectothermic species is expected (Collins and Mclntyre 2015).

Temperature has a significant impact on Odonates life histories since it serves as a cue for adult emergence and reproduction (Packauskas 2005, Tennessen 2019a).

The Intergovernmental Panel on Climate Change (IPCC, 2018) reported that, human activities are estimated to have increased global temperatures approximately by 1.5°C. Since temperature variables are a key in determining the potential HED suitable habitat, any increase in earth temperature will result in changes of these suitable habitats.

Three precipitation variables have an accumulated contribution of 44.4% (Table 2.5), precipitation of warmest quarter, precipitation of driest quarter, and precipitation seasonality. Precipitation of less than 130mm in the warmest quarter greatly reduced the probability of the presence of HED (Table 2.8). Precipitation less than 85mm in the driest quarter also greatly reduced HED presence probability (Fig. 2.8, Table 2.5). Collins and Mclntyre (2015) reported that precipitation seasonality affects freshwater species since it affects hydroperiods of lentic habitats. Generally, environmental factors representing temperature have more influence on the HED distribution than variables representing precipitation (Tables 2.7 & 2.8). Precipitation can influence dissolved oxygen concentration and water temperature (Utz et al. 2020).

Predicted Suitable Habitat of the Hudsonian Emerald

The high AUC values of the four different modelling strategies (Table 2.3) indicated that Maxent had good ability for recognizing areas with elevated potential suitability for HED occurrence. The 2019-2021 sampling seasons and added eleven new occurrence sites within the study area (Fig. 2.9, Table 2.6). The six new occurrence records (sites) obtained in summer 2019 were used in building the model, while the five records (sites) obtained in summer of 2020 and 2021 were used in model validation. all these new occurrence records were in areas that had been classified by the Maxent model as having medium to height suitability for the HED (Fig. 2.9, Table 2.6).

The potential suitable habitat of the HED as in Northcentral Colorado as predicted by the Maxent (Fig. 2.9), mostly located to the east of the Continental Divide. Areas of high suitability includes parts of James Peak Wilderness, Indian Peak Wilderness, Cameron Peak Wilderness, Rawah Wilderness in ARNF. All HED 2019-2021 occurrence records were obtained from lakes with an elevation range of 2,750-3,250m in these areas (Table 2.6). I predicted to find the HED in many lakes in these areas, since many of these lakes have high potential suitability for HED and the same habitat characteristics that found in the lakes where HED was recorded (macrophytes, lake depth, rocky bottom, and short distance to tree cover). Here I listed some lakes that have high habitat suitability for HED: Boulder County; Lost Lake, Long Lake, ponds near Mitchell Lake, Red Deer Lake, and wetlands near Middle Saint Vrain Creek; Grand County: Strawberry Lake, Monarch Lake, and Watanga Lake; Larimer County: Camp Lake, Upper Sandbar Lake, Lower Sandbar Lake, and Lily Pond Lake.

The potential suitable habitat of the HED as in southern Wyoming as predicted by the Maxent (Fig. 2.9), mostly located to the east of the near the Medicine Bow Mountain. Areas of high suitability includes parts of lakes near the North Fork Laramie River, and Fire Box Lake in Albany County, and the lily ponds and lakes near Long Lake and Turpin Reservoir in Carbon County (Fig. 2.9).

The potential distribution of *S. hudsonica* will be an important aspect for the US Forest Service to implement conservation programs for this vulnerable species in the two national forests of Northcentral Colorado and southern Wyoming. Additionally, more surveys for the HED should be made, especially at the western and southern edges of the study area since many parts of these areas have been classified as having potentially medium suitability for HED. Species at the edge of their range as the HED in Northcentral Colorado are likely to be vulnerable to climate change effects since smaller populations have a higher risk of extirpation from climatic disturbances (Williams et al. 2008, Bush et al. 2014 b). Although habitat suitability models provide a useful tool for conservation assessments (Bush et al. 2014b), further research on the effects of climate change scenarios on community dynamics are needed (Parain et al., 2019). To conserve rare invertebrates, we also recommended that fisheries managers strongly consider rare and vulnerable invertebrate taxa, such as the HED when determining suitable locations for stocking salmonids.

Additional surveys for HED should be made at the high-elevation lakes affected by the recent massive wildfires of 2020, the East Troublesome Fire, the Cameron Peak Fire, and Mullen Fire (Colorado Encyclopedia, https://coloradoencyclopedia.org/article/wildfire-colorado) to identify the effects of these wildfires on this species. Since species like the HED is likely to be vulnerable to environmental change, it is highly suggested to determine how future distributions of the HED will respond to both stochastic and catastrophic environmental changes and climate change scenarios.

FIGURES AND TABLES

Figure 2. 1. Hudsonian Emerald, *Somatochlora hudsonica*, a male, Rainbow Lakes, lower lake, Boulder County, Colorado. 30 July 2021. Photograph by M. Al Mousa.

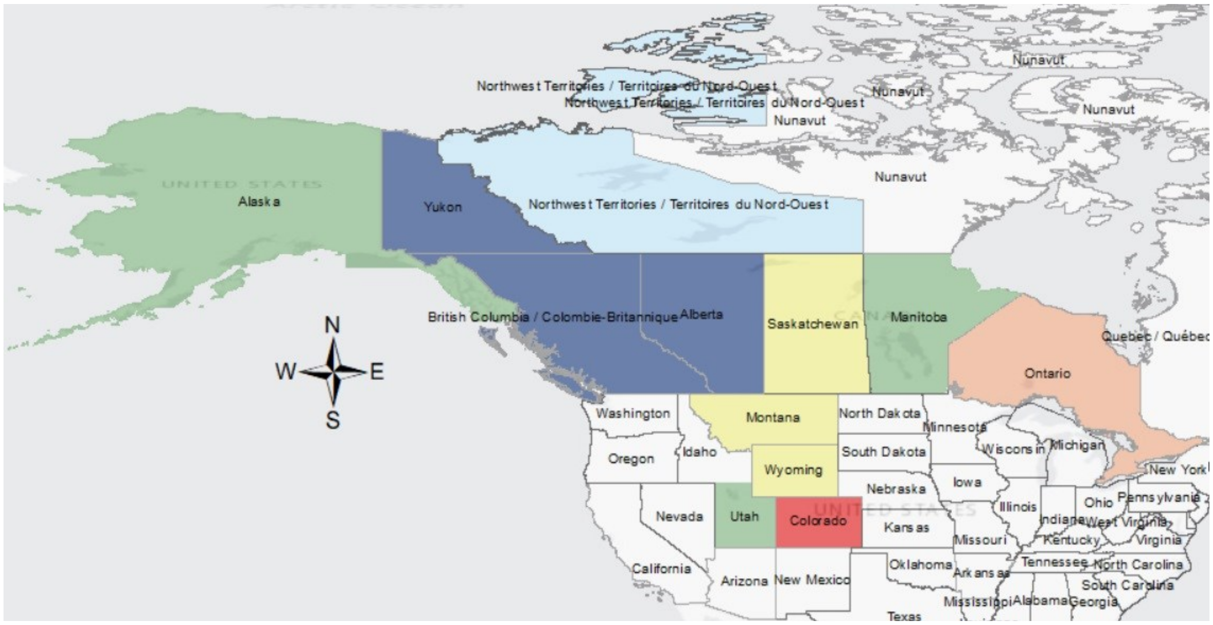

Fig. 2.2 Distribution and status of the Hudsonian Emerald, *Somatochlora hudsonica*. (NatureServe 2020 https://explorer.natureserve.org/. Accessed: December 13, 2020). Dark blue (Secure S5), light blue (Apparently Secure S4), orange (Vulnerable S3), yellow (Imperiled S2), red (Critically Impered S1), and green (No Status Rank SNR/SU/SNA).

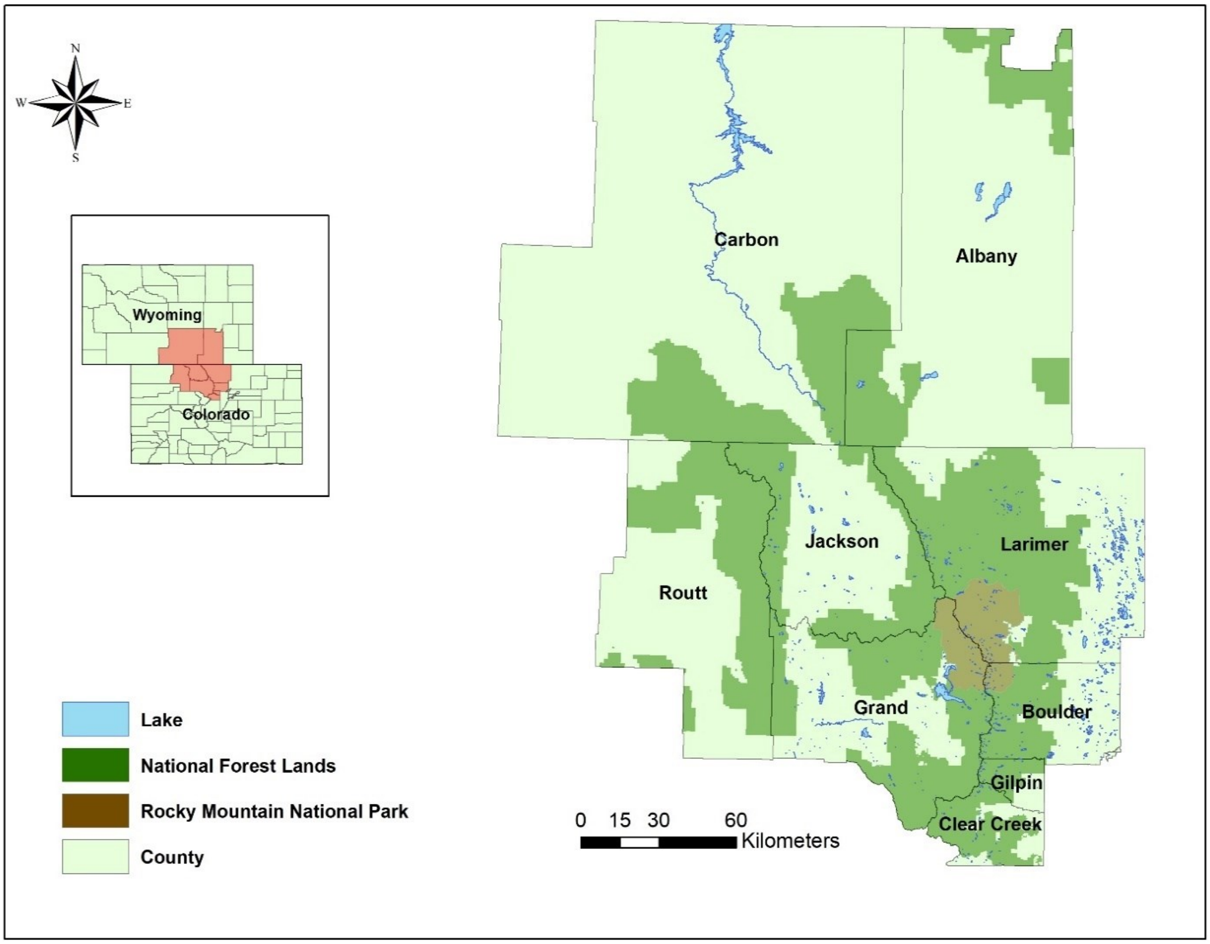

Figure 2.3. Study area of the Hudsonian Emerald Dragonfly in the Arapahoe & Roosevelt National Forest and Medicine Bow & Routt National Forest, Northcentral Colorado and southern Wyoming, USA.

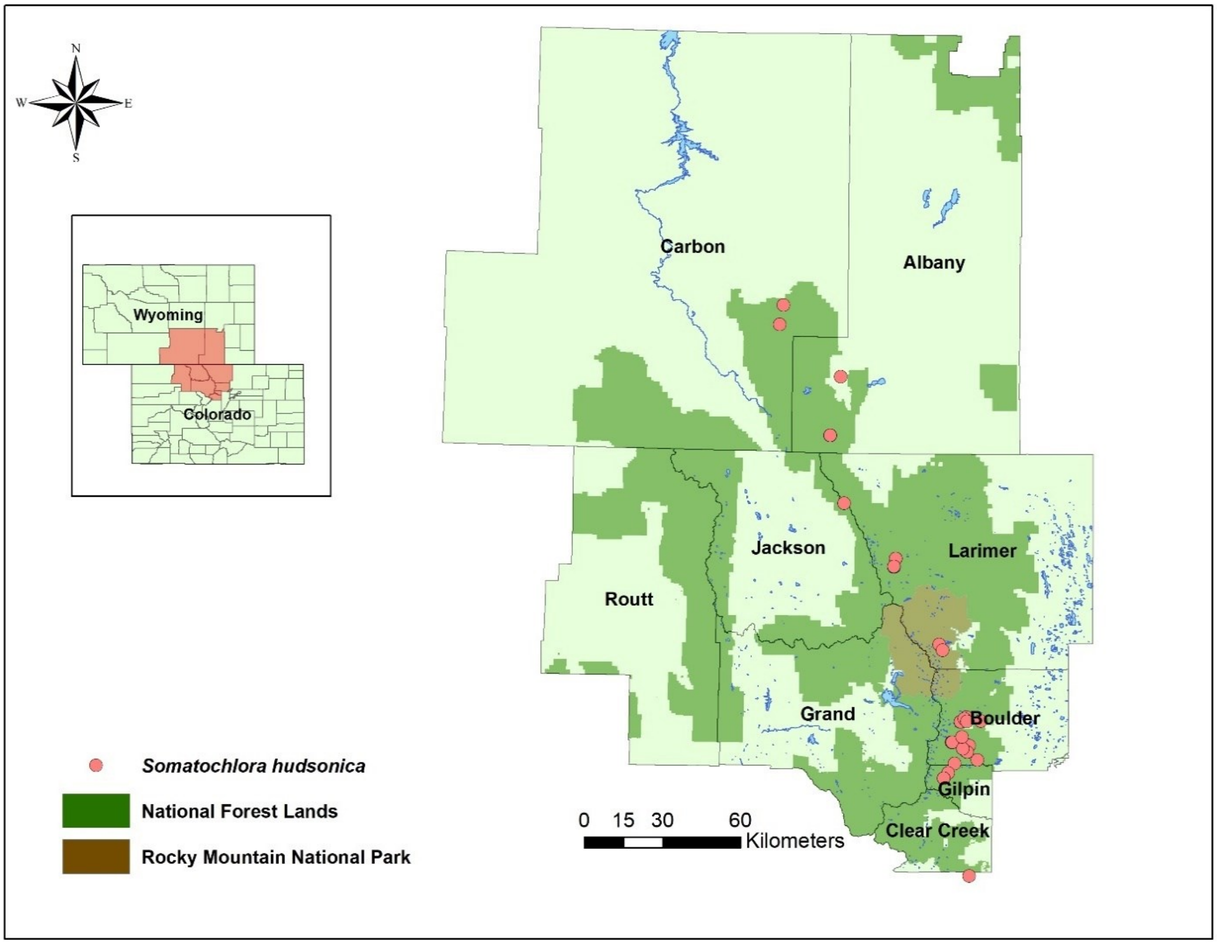

Figure 2.4. Distribution map, and presence records of the Hudsonian Emerald dragonfly, *Somatochlora hudsonica* in the Arapaho & Roosevelt National Forest and the Medicine Bow & Routt National Forest, Northcentral Colorado and southern Wyoming, USA, 2019. Red circles represents all HED previous presence records and 2019 samplig season records (these records were used in the Maxent model.

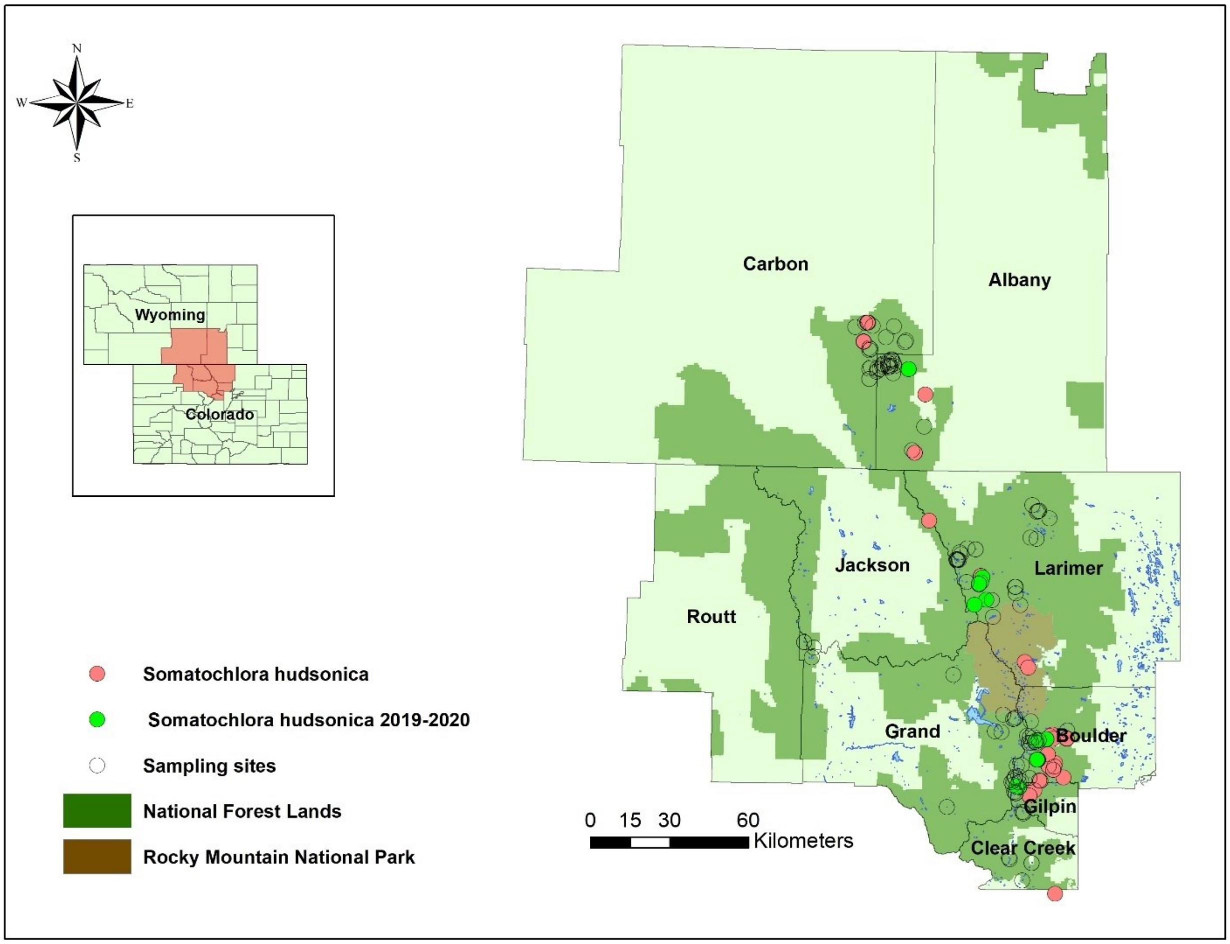

Figure 2.5. Distribution map, sampling sites, and presence records of the Hudsonian Emerald dragonfly, *Somatochlora hudsonica* in the Arapaho & Roosevelt National Forest and the Medicine Bow & Routt National Forest, Northcentral Colorado and southern Wyoming, USA, 2021.

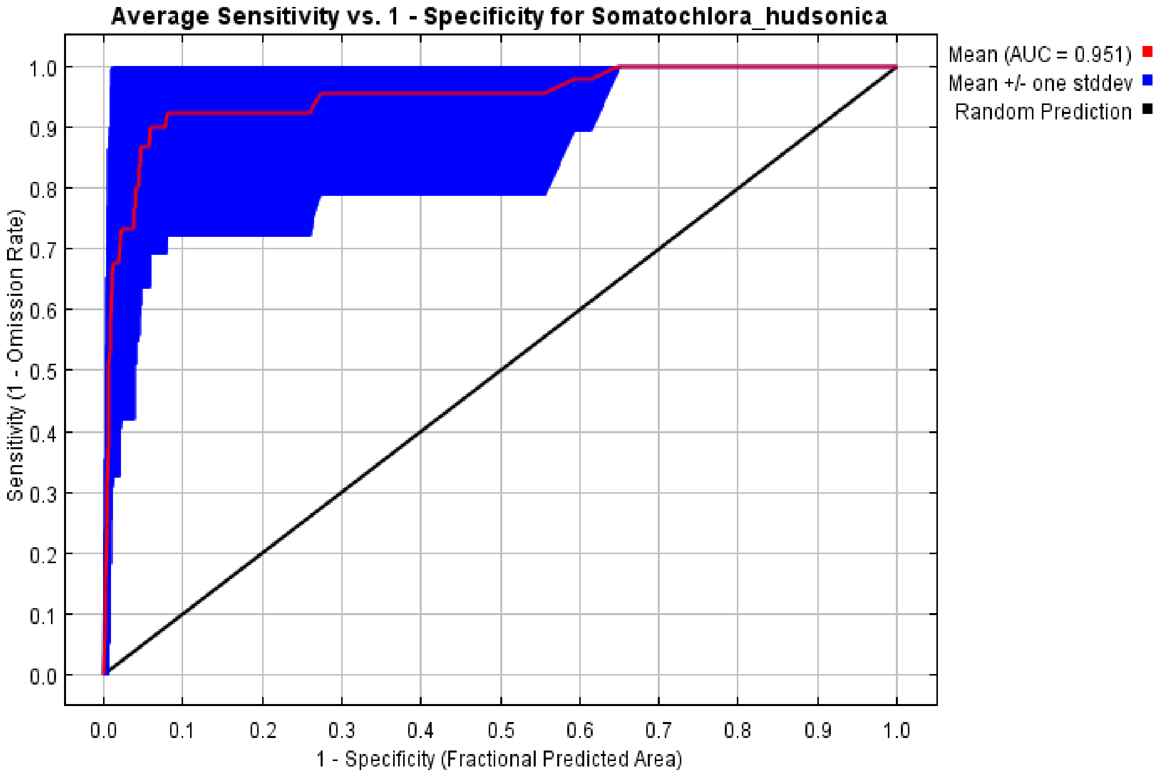

Figure 2.6. The AUC result of the MaxEnt model for the Hudsonian Emerald, *Somatochlora hudsonica* in the Arapaho & Roosevelt National Forest and the Medicine-Bow & Routt National Forest, Northcentral Colorado and southern Wyoming, USA.

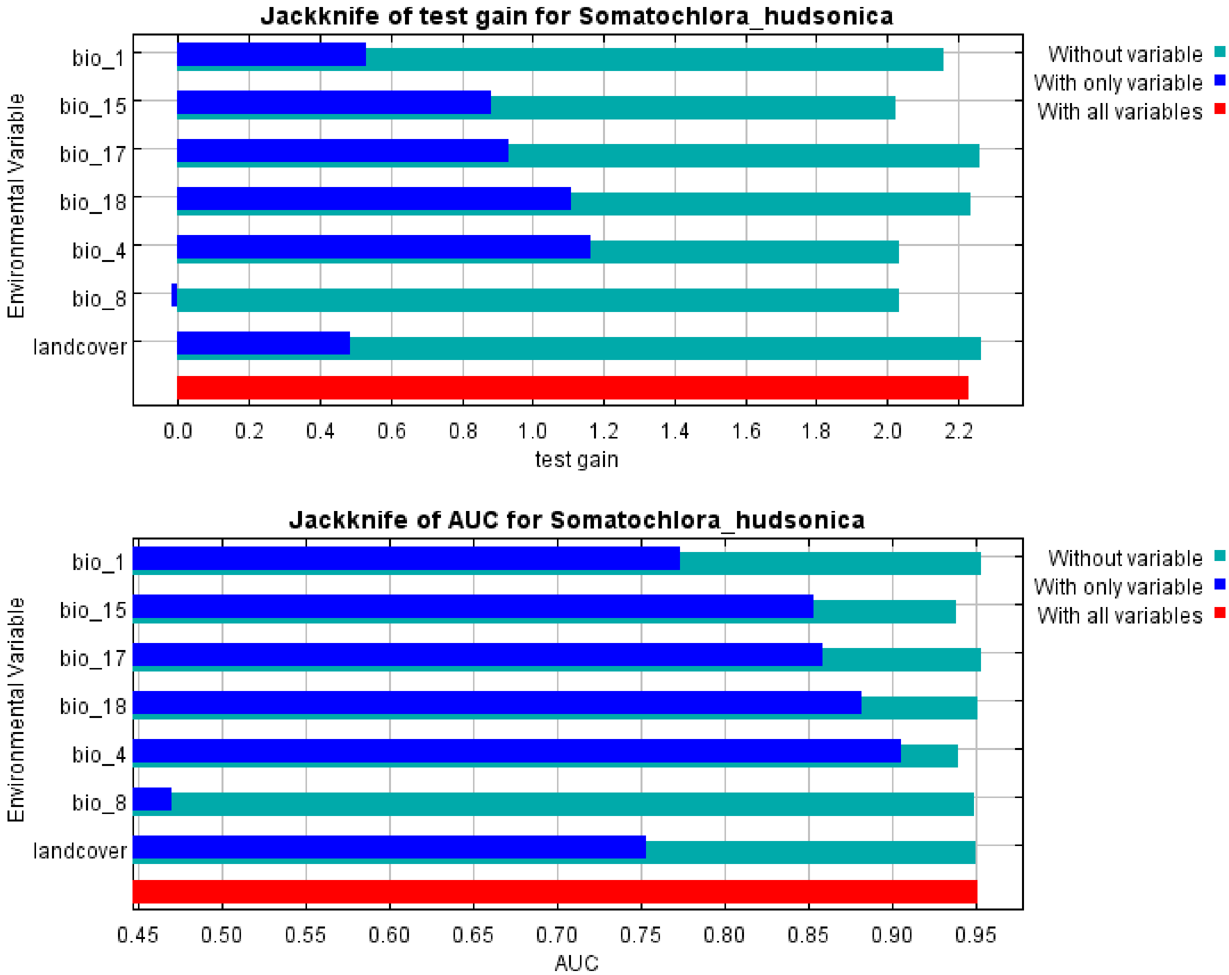

Figure 2.7. The importance of environmental variables (Annual mean temperature Bio_1, Temperature seasonality Bio_4, Mean temperature of wettest quarter Bio_8, Precipitation seasonality Bio_15, Precipitation of driest quarter Bio_17, and Precipitation of warmest quarte Bio_18) to the distribution the Hudsonian Emerald, *Somatochlora hudsonica* in the Arapaho & Roosevelt National Forest and the Medicine-Bow & Routt National Forest, Northcentral Colorado, and southern Wyoming (USA) by the Jackknife analysis.

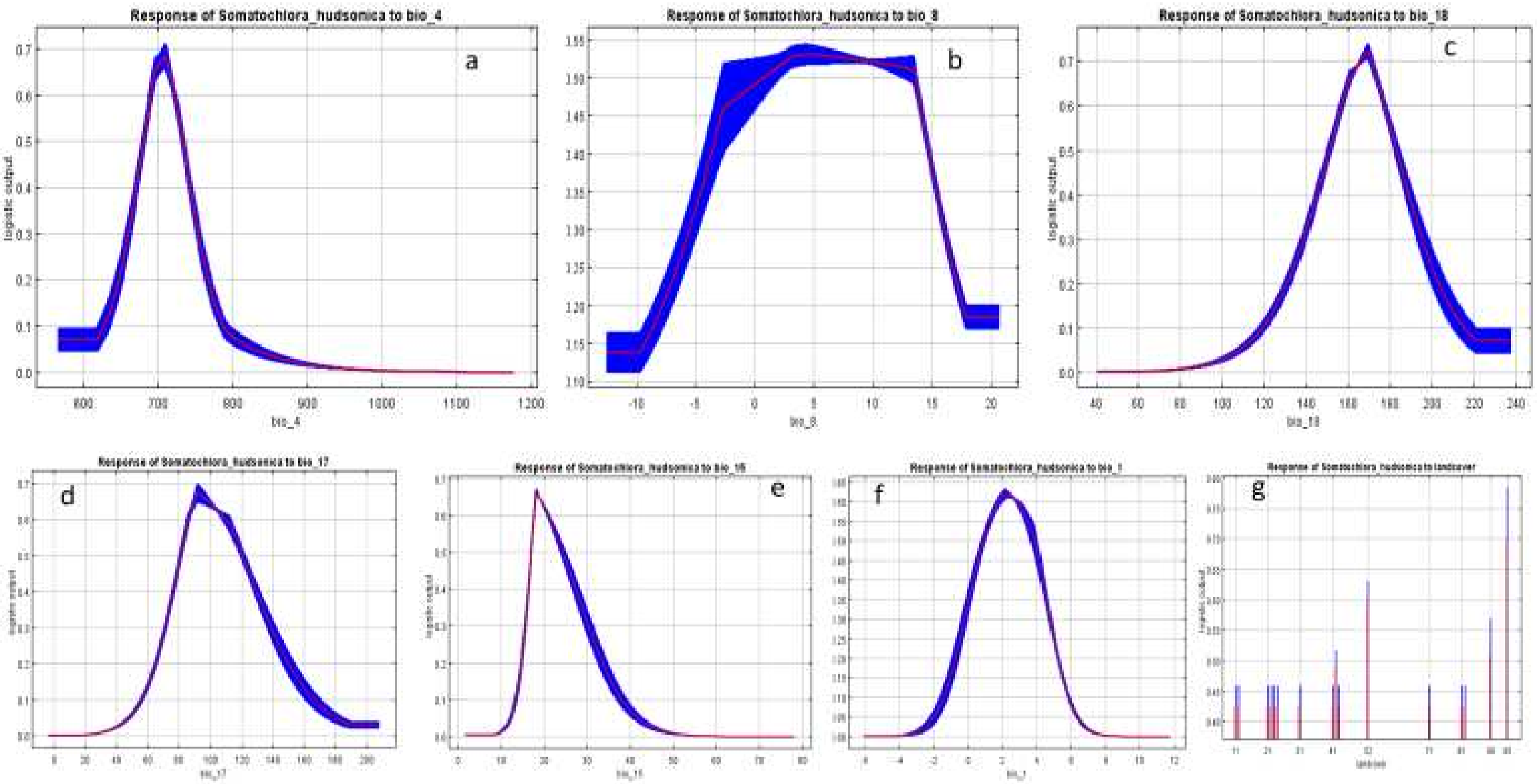

Figure 2.8. Response curves for the important environmental factors in the species distribution model of the Hudsonian Emerald, *Somatochlora hudsonica* in the Arapaho & Roosevelt National Forest and the Medicine-Bow & Routt National Forest, Northcentral Colorado and southern Wyoming, USA. (a) Temperature seasonality, (b) Mean temperature of wettest quarter, (c) Precipitation of warmest quarter, (d) precipitation of driest quarter, (e) Precipitation seasonality, (f) Annual mean temperature, and (g) Tree canopy cover.

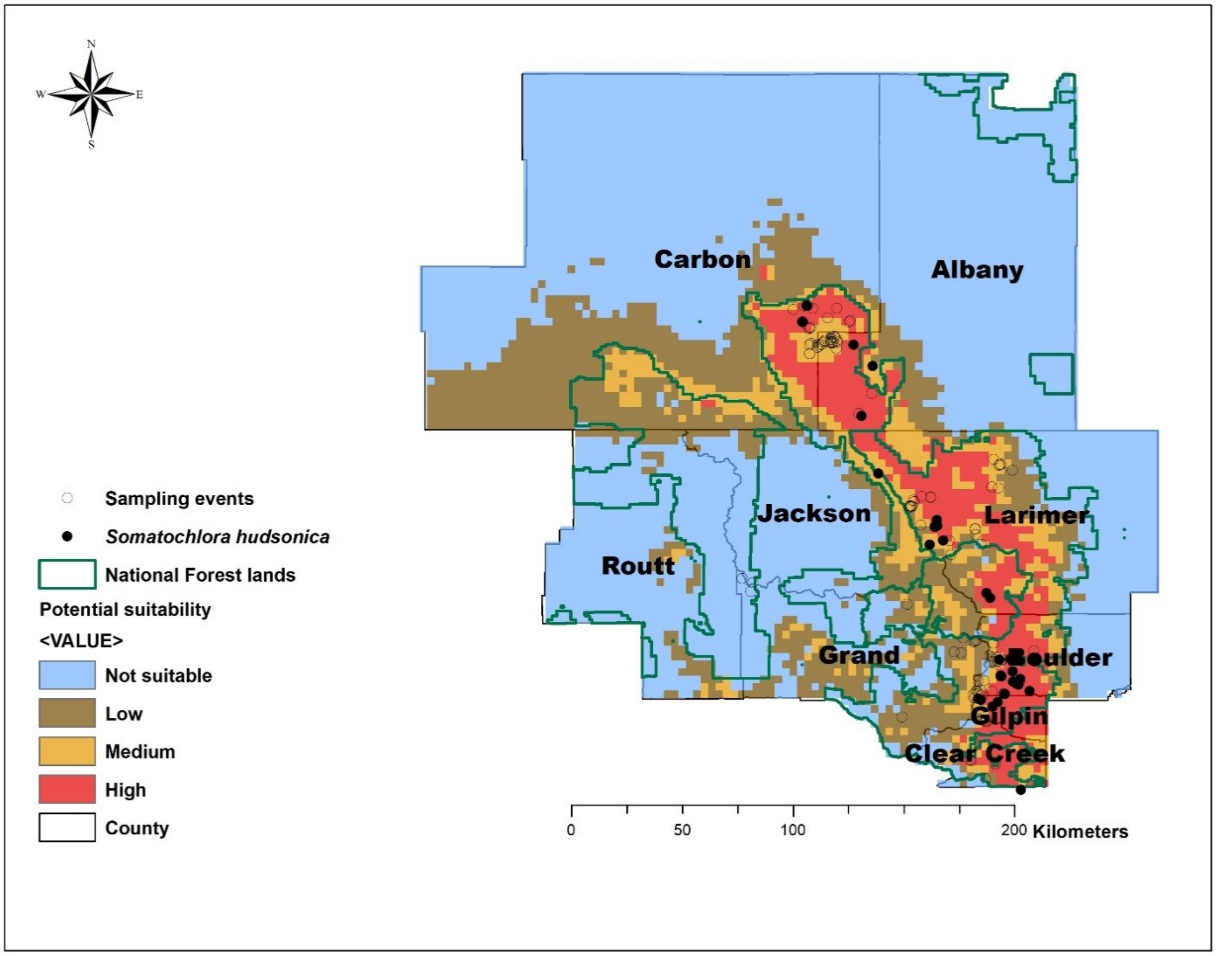

Figure 2.9. Potential suitable distribution of *Somatochlora hudsonica* in Northcentral Colorado and southern Wyoming, USA. Blue color indicates not suitable habitat, brown indicates low suitability, orange indicates medium suitability, red represents high suitability, opened circles represent sampling events, and closed circles represent presence records of *Somatochlora hudsonica*.

Table 2.1. Sampling sites, elevations, and water parameters of lakes sampled for the Hudsonian Emerald dragonfly, *Somatochlora hudsonica* of montane and alpine lakes (following Pennak 1969) in Northcentral Colorado and southern Wyoming, USA, 2021.

Lake	County	Elevation (m)	Sampling date	Conductivity uS/cm	pH	Salinity ppm	TDS ppm	Water Temp. (˚C)
Red Rock Lake	Boulder	3,100	10-VII-2019	29.0	9.2	0	0.0220	17.0
Brainard Lake	Boulder	3,154	10-VII-2019	15.5	9.3	0	0.0118	13.8
Rainbow Lakes, lower	Boulder	3,098	10-VII-2019	27.5	8.9	0	0.0188	23.0
Mud Lake	Boulder	2,552	16-VII-2019	10.5	9.1	0	0.0771	19.7
Delonde ponds	Boulder	2,602	16-VII-2019	NA				
Brainard Lake	Boulder	3,154	17-VII-2019	17.0	8.8	0	0.0118	11.1
Red Rock Lake*	Boulder	3,100	17-VII-2019	30.0	8.9	0	0.0220	19.2
Long Lake	Boulder	3,212	17-VII-2019	11.0	9.1	0	0.0101	10.7
Gold Lake	Boulder	2,627	18-VII-2019	15.0	8.9	0	0.0127	14.3
Lake Eldora	Boulder	2,831	18-VII-2019	18.0	9.0	0	0.0130	13.2
Peterson Lake, Eldora	Boulder	2,823	18-VII-2019	19.1	8.9	0	0.0122	13.4
Rainbow Lakes, lower	Boulder	2,098	23-VII-2019	37.6	7.8	0	0.0272	19.7
Rainbow Lakes, middle *	Boulder	3,110	23-VII-2019	31.5	8.2	0	0.0233	18.3
Rainbow Lakes, upper	Boulder	3,127	23-VII-2019	17.5	7.7	0	0.0154	11.4
Lost Lake	Boulder	2,985	14-VIII-2019	53.7	8.8	0	0.0357	19.7
Woodland Lake	Boulder	3,348	14-VIII-2019	19.1	9.6	0	0.0125	13.9
Jenny Lake	Boulder	3,332	15-VIII-2019	24.2	7.5	0	0.0159	11.8
Yankee Doodle Lake	Boulder	3,268	15-VIII-2019	53.7	8.8	0	0.0357	19.0
Red Rock Lake*	Boulder	3,100	20-VIII-2019	30.2	9.5	0	0.0243	19.6
Brainard Lake	Boulder	3,154	20-VIII-2019	17.5	9.3	0	0.0121	17.2
Long Lake	Boulder	3,212	20-VIII-2019	17.0	8.9	0	0.0117	16.4
Lake Isabelle	Boulder	3,325	20-VIII-2019	14.7	8.7	0	0.0097	13.2
wetland, L. Isabelle Trail	Boulder	3,100	20-VIII-2019	17.7	8.8	0	0.0117	15.6
Crater Lakes, lower N.	Gilpin	3,230	08-VIII-2019	17.8	8.7	0	0.0122	16.0
Crater Lakes, lower S.	Gilpin	3,225	08-VIII-2019	18.1	8.7	0	0.0118	14.3

Crater Lakes, upper	Gilpin	3,357	08-VIII-2019	21.9	7.0	0	0.0125	13.1
Forest Lakes, upper	Gilpin	3,308	08-VIII-2019	22.0	7.0	0	0.0125	14.0
Forest Lakes, lower	Gilpin	3,245	08-VIII-2019	15.3	8.7	0	0.0121	16.0
Forest Lakes, upper	Gilpin	3,308	15-VIII-2019	20.5	9.2	0	0.0137	15.7
Forest Lakes, lower*	Gilpin	3,245	15-VIII-2019	15.3	8.6	0	0.0101	16.2
Forest Lakes, middle*	Gilpin	3,257	15-VIII-2019	73.7	8.9	0	0.0487	14.7
Horseshoe Lake, Parshall	Grand	3,420	13-VIII-2019	16.2	8.9	0	0.0120	15.3
wetland, near Stone Lake	Grand	3,200	17-VIII-2019	14.3	9.3	0	0.0094	14.4
Stone Lake	Grand	3,240	17-VIII-2019	11.1	8.7	0	0.0072	14.2
Upper Lake	Grand	3,270	17-VIII-2019	16.7	9.9	0	0.0110	14.9
Lost Lake, FS456	Grand	2,943	21-IX-2019	25.3	8.6	0	0.0145	16.2
Watanga Lake	Grand	3,283	30-VIII-2019	23.3	9.4	0	0.0153	17.5
Strawberry Lake	Grand	2,800	30-VIII-2019	17.7	8.8	0	0.0117	15.6
Lost Lake, Co Rd 103	Larimer	2,835	21-VI-2019	48.6	9.2	0	0.0417	12.6
Creedmore Lakes, L#2	Larimer	2,542	09-VII-2019	53.1	8.8	0	0.0379	21.4
Lost Lake, Co Rd 103*	Larimer	2,835	24-VII-2019	55.6	8.3	0	0.0471	21.2
Laramie Lake, Rd 103*	Larimer	2,845	24-VII-2019	41.4	8.8	0	0.0294	20.8
Twin Lakes*	Larimer	2,895	24-VII-2019	39.2	7.1	0	0.0229	19.3
Trap Lake*	Larimer	3,030	24-VII-2019	32.4	9.1	0	0.0253	16.3
Peterson Lake	Larimer	2,896	30-VII-2019	19.2	7.4	0	0.0145	18.7
Lost Lake, Rawah Trail	Larimer	3,100	31-VII-2019	16.9	8.4	0	0.0122	18.8
Pond, near Lost L., Rawah Trail	Larimer	3,160	31-VII-2019	NA				
Lily Pond Lake, Rd 103	Larimer	2,600	31-VII-2019	35.6	8.6	0	0.0232	20.9
Timberline Lake	Larimer	3,210	07-VIII-2019	19.4	9.7	0	0.0127	16.7
Browns Lake	Larimer	3,210	07-VIII-2019	19.3	9.3	0	0.0129	15.7
Comanche Lake	Larimer	3,043	07-VIII-2019	11.3	9.0	0	0.0074	17.9
Lost L. Red Feather Lakes	Larimer	2,450	22-VIII-2019	77.8	8.5	0	0.0922	19.9
Creedmore Lakes, L#2	Larimer	2,542	22-VIII-2019	53.1	8.8	0	0.0379	19.7

Creedmore Lakes, L#1	Larimer	2,533	22-VIII-2019	39.1	8.9	0	0.0352	20.2
Creedmore Lakes, L#3	Larimer	2,538	22-VIII-2019	38.2	8.8	0	0.0379	19.1
Emmaline Lake	Larimer	3,356	25-VIII-2019	11.4	9.5	0	0.0076	6.2
Cirque Lake	Larimer	3,334	25-VIII-2019	20.5	9.2	0	0.0135	9.1
Lost Lake, Co Rd 103	Larimer	2,835	02-IX-2019	51.3	9.2	0	0.0412	19.3
Trap Lake	Larimer	3,030	02-IX-2019	32.0	9.1	0	0.0245	18.2
Lily Pond Lake, Rd 103	Larimer	2,600	02-IX-2019	33.2	8.9	0	0.0417	19.0
Red Rock Lake	Boulder	3,100	09-VII-2020	32.6	7.4	0	0.0126	19.5
Brainard Lake	Boulder	3,154	09-VII-2020	17.3	7.6	0	0.0113	15.1
Lake Isabelle	Boulder	3,325	09-VII-2020	15.8	7.6	0	0.0104	10.7
Long Lake	Boulder	3,212	09-VII-2020	16.7	8.3	0	0.0110	12.0
Left Hand Reservoir	Boulder	3,250	09-VII-2020	NA				
Bob Lake	Boulder	3,525	11-VII-2020	16.2	9.2	0	0.0108	3.6
Betty Lake	Boulder	3,484	11-VII-2020	16.7	8.3	0	0.0111	11.8
King Lake	Boulder	3,482	11-VII-2020	13.0	6.5	0	0.0087	8.5
Diamond Lake	Boulder	3,342	17-VII-2020	25.1	7.6	0	0.0165	13.0
Upper Diamond Lake	Boulder	3,575	17-VII-2020	20.6	9.6	0	0.0128	7.2
Lost Lake, Hessie Trail	Boulder	2,985	04-VIII-2020	52.1	8.7	0	0.0345	16.5
Mud Lake	Boulder	2,552	04-VIII-2020	55.9	8.1	0	0.0352	17.1
Red Rock Lake*	Boulder	3,100	04-VIII-2020	57.2	8.8	0	0.0342	18.7
pond, SW of Mitchell L.	Boulder	3,315	07-VIII-2020	NA				
Little Blue Lake	Boulder	3,616	07-VIII-2020	7.0	8.9	0	0.0046	9.9
Blue Lake	Boulder	3,460	07-VIII-2020	8.9	9.6	0	0.0059	11.0
Mitchell Lake	Boulder	3,268	07-VIII-2020	18.1	8.7	0	0.0117	15.2
Brainard Lake	Boulder	3,154	07-VIII-2020	43.1	9.1	0	0.0211	16.2
Red Rock Lake*	Boulder	3,100	07-VIII-2020	58.2	8.8	0	0.0341	19.0
Rock Lake	Boulder	2,645	08-VIII-2020	NA				
Red Deer Lake	Boulder	3,164	08-VIII-2020	13.1	8.3	0	0.0086	13.7
Echo Lake	clear Creek	3,236	08-VII-2020	19.2	8.6	0	0.0744	16.7

Lake Quivira	clear Creek	3,152	08-VII-2020	18.2	7.6	0	0.0221	12.1
Silver Lake	clear Creek	3,160	08-VII-2020	Private				
Saint Mary's Lake	clear Creek	3,270	08-VII-2020	15.1	7.2	0	0.0521	10.2
Green Lake	clear Creek	3,026	15-VII-2020	89.9	8.6	0	0.0593	14.2
Clear Lake	clear Creek	3,003	15-VII-2020	92.1	8.5	0	0.0471	14.5
Echo Lake	clear Creek	3,236	15-VII-2020	47.0	8.6	0	0.0521	18.2
Snow Line Lake	Gilpin	2,744	23-VI-2020	Private				
Crater Lakes, lower N	Gilpin	3,230	24-VII-2020	17.5	8.7	0	0.0109	14.4
Crater Lakes, lower S	Gilpin	3,225	24-VII-2020	17.1	9.0	0	0.0113	14.3
Crater Lakes, upper	Gilpin	3,357	24-VII-2020	17.1	8.8	0	0.0121	12.7
Corona Lake	Grand	3,420	11-VII-2020	16.2	8.0	0	0.0112	12.3
Pumphouse Lake	Grand	3,460	11-VII-2020	15.3	8.1	0	0.0092	12.1
Monarch Lake	Grand	2,542	11-VII-2020	69.2	7.7	0	0.0654	18.3
Lake Agnes	Grand	2,675	18-VII-2020	Private				
Dumont Lake	Grand	2,900	18-VII-2020	41.3	8.1	0	0.0273	18.5
Lake Evelyn	Grand	3,395	19-VII-2020	32.7	9.1	0	0.0217	16.5
Muddy Pass Lake	Jackson	2,675	18-VII-2020	146.8	8.9	0.1	0.1058	20.5
Zimmerman Lake	Larimer	3,196	27-VI-2020	NA				
Blue Lake	Larimer	3,252	07-VII-2020	53.8	6.9	0	0.0328	16.1
Lost Lake, Rd 103*	Larimer	2,835	07-VII-2020	64.8	6.8	0	0.0422	19.1
Lost L. Red Feather Lakes	Larimer	2,450	09-VIII-2020	212.1	8.1	0	0.1023	23.1
Creedmore Lakes, L#2	Larimer	2,542	09-VIII-2020	66.6	6.8	0	0.0442	20.0
Creedmore Lakes, L#1	Larimer	2,533	09-VIII-2020	196.2	6.9	0	0.0592	20.4
Creedmore Lakes, L#3	Larimer	2,538	09-VIII-2020	208.1	6.7	0	0.0621	20.3
Bellaire Lake	Larimer	2,636	09-VIII-2020	66.9	6.9	0.1	0.0452	19.9

Molly Lake	Larimer	2,513	09-VIII-2020	187.9	6.7	0.1	0.0533	20.3
Trap Lake, Long Draw Rd	Larimer	3,030	29-VII-2020	256.3	8.7	0	0.2345	18.3
Peterson Lake	Larimer	2,896	29-VII-2020	142.3	9.1	0	0.0769	19.0
Long Draw Reservoir	Larimer	3,080	29-VII-2020	NA				
Rawah Lakes, L#2	Larimer	3,273	13-VIII-2020	12.2	8.1	0	0.0081	15.6
Rawah Lakes, L#1	Larimer	3,260	13-VIII-2020	25.3	7.9	0	0.0122	17.2
pond off Rawah Trail	Larimer	2,918	13-VIII-2020	NA				
Upper Sandbar Lake	Larimer	3,262	13-VIII-2020	19.6	8.3	0	0.0129	17.0
Lower Sandbar Lake	Larimer	3,252	13-VIII-2020	45.3	7.9	0	0.0127	17.6
Camp Lake	Larimer	3,260	13-VIII-2020	57.1	8.2	0	0.0131	18.2
Big Rainbow Lake	Larimer	3,270	13-VIII-2020	14.9	8.3	0	0.0097	14.8
Red Rock Lake*	Boulder	3,100	25-VI-2021	28.2	9.0	0	0.0220	15.6
Brainard Lake	Boulder	3,154	25-VI-2021	16.9	8.6	0	0.0109	9.9
Lake Isabelle	Boulder	3,325	25-VI-2021	14.0	9.0	0	0.0090	6.1
Long Lake	Boulder	3,212	25-VI-2021	15.9	9.0	0	0.0103	9.2
Rainbow Lakes, lower	Boulder	2,098	03-VII-2021	37.4	8.2	0	0.0240	15.1
Rainbow Lakes, middle	Boulder	3,110	03-VII-2021	32.2	8.3	0	0.0206	14.4
Rainbow Lakes, upper	Boulder	3,127	03-VII-2021	20.9	10.3	0	0.0134	8.8
Red Rock Lake	Boulder	3,100	25-VII-2021	31.2	9.0	0	0.0412	20.1
Brainard Lake	Boulder	3,154	25-VII-2021	19.9	8.7	0	0.0192	17.3
Lake Isabelle	Boulder	3,325	25-VII-2021	19.2	9.0	0	0.0122	12.2
Long Lake	Boulder	3,212	25-VII-2021	30.1	9.0	0	0.0542	17.0
Blue Lake	Boulder	3,460	25-VII-2021	9.4	9.3	0	0.0159	12.0
Mitchell Lake	Boulder	3,268	25-VII-2021	18.1	8.8	0	0.0182	19.2
Rainbow Lakes, lower*	Boulder	2,098	30-VII-2021	39.3	8.0	0.0	0.0224	18.0
Rainbow Lakes, middle*	Boulder	3,110	30-VII-2021	35.0	7.9	0.0	0.0206	17.7
Rainbow Lakes, upper*	Boulder	3,127	30-VII-2021	22.5	9.1	0.0	0.0134	17.9
Red Rock Lake	Boulder	3,100	14-VI1I-2021	31.9	8.9	0.0	0.0412	18.1

Brainard Lake	Boulder	3,154	14-VI1I-2021	26.9	8.7	0.0	0.0192	16.5
Lake Isabelle	Boulder	3,325	14-VI1I-2021	22.2	8.9	0.0	0.0122	12.0
Long Lake	Boulder	3,212	14-VI1I-2021	34.1	8.9	0.0	0.0542	16.5
Blue Lake	Boulder	3,460	14-VI1I-2021	9.4	9.1	0.0	0.0159	13.0
Little Blue Lake	Boulder	3,616	14-VI1I-2021	8.3	8.9	0.0	0.0084	12.1
Mitchell Lake	Boulder	3,268	14-VI1I-2021	22.1	8.9	0.0	0.0212	16.2
Pond, W of Mitchell Lake	Boulder	3,270	14-VI1I-2021	81.3	8.8	0.0	0.0232	16.4
Pond, W of Long Lake*	Boulder	3,100	14-VI1I-2021	102.5	9.0	0.0	0.285	16.3
Summit Lake	Clear Creek	3,910	11-VII-2021	NA				
Echo Lake	Clear Creek	3,236	11-VII-2021	NA				
Forest Lakes, lower*	Gilpin	3,245	28-VII-2021	22.5	9.0	0.0	0.0216	18.7
Forest Lakes, middle*	Gilpin	3,255	28-VII-2021	16.9	8.7	0.0	0.0101	17.4
Forest Lakes, upper*	Gilpin	3,307	28-VII-2021	75.9	8.9	0.0	0.0487	15.7
Lost Lake, Co Rd 103	Larimer	2,835	05-VII-2021	101.1	8.9	0.1	0.0647	18.5
Lily Pond Lake, Co Rd 103	Larimer	2,600	05-VII-2021	41.6	8.7	0.0	0.0322	20.1
Lost Lake, Co Rd 103	Larimer	2,835	17-VII-2021	101.1	8.9	0.1	0.0647	18.5
Zimmerman Lake*	Larimer	3,196	17-VII-2021	24.9	9.9	0.0	0.0160	15.7
Lost Lake, Co Rd 103	Larimer	2,835	08-VIII-2021	92.2	8.9	0.1	0.0588	15.1
Trap Lake, Long Draw Rd	Larimer	3,030	08-VIII-2021	34.3	9.1	0.0	0.0219	12.8
Peterson Lake	Larimer	2,896	08-VIII-2021	40.7	8.8	0.0	0.0261	15.7
Bellaire Lake	Larimer	2,636	08-VIII-2021	72.3	7.8	0.1	0.0532	18.7

Lost Lake, Co Rd 103	Larimer	2,835	12-VIII-2021	95.1	8.9	0.1	0.0589	16.5
Trap Lake, Long Draw Rd	Larimer	3,030	12-VIII-2021	38.1	9.0	0.1	0.0647	14.7
Wyoming								
Hanging Lake*	Albany	2,770	22-VII-2020	242.1	8.2	0.1	0.1598	19.6
Little Broklyn Lake	Albany	3,155	22-VII-2020	87	8.3	0	0.0578	13.8
East Glacier Lake	Albany	3,287	22-VII-2020	7.5	9.1	0	0.005	16.3
Broklyn Lake	Albany	3,213	22-VII-2020	11.2	8.9	0	0.0121	16.4
West Glacier Lake	Albany	3,280	22-VII-2020	6.4	9.1	0	0.0053	13.4
Telephone Lakes	Albany	3,268	22-VII-2020	19.1	7.9	0	0.0127	15.8
Lost Lake	Albany	3,337	22-VII-2020	10.4	8.2	0	0.0068	13.9
Lake Owen	Albany	2,730	25-VII-2020	31.7	7.7	0	0.021	15.5
Miller Lak	Albany	2,764	25-VII-2020	110.9	7.1	0.1	0.0727	17.5
Fishhook Lake	Albany	3,233	26-VII-2020	NA				
Jeep Lake	Albany	3,242	26-VII-2020	NA				
Libby Lake	Albany	3,274	26-VII-2020	136.2	7.1	0	0.0289	13.9
Lewis Lake	Albany	3,279	26-VII-2020	122.3	7.2	0	0.0254	13.6
Class Lake	Albany	3,281	26-VII-2020	109.1	7.4	0	0.0112	13.1
Hanging Lake	Albany	2,770	07-VIII-2020	265	8.2	0.1	0.1786	21.1
Hourglass Lake	Albany	3,202	07-VIII-2020	154.7	8.3	0.1	0.1029	19.2
Bellamy Lake	Albany	3,246	07-VIII-2020	48.3	7.9	0	0.0329	15.6
Towner Lake	Albany	3,195	07-VIII-2020	90.5	7	0	0.0597	14.9
Mill pond Lake	Albany	3,141	07-VIII-2020	86.1	8.1	0	0.0322	15.2
Highway 130	Albany	3,196	07-VIII-2020	161.8	7.6	0.1	0.1065	21.6
Bear Lake	Albany	3,083	16-VIII-2020	17.1	7.8	0	0.0113	18.8
Lookout Lake	Albany	3,237	16-VIII-2020	11.3	8.1	0	0.0074	13.6
Mirror Lake	Albany	3,217	16-VIII-2020	NA				
Long Lake	Carbon	2,725	26-VII-2020	28.3	8.5	0	0.0188	16.3
Silver lake	Carbon	3,153	26-VII-2020	21.5	8.6	0	0.0122	14.9
Lily pond, N of Long L.	Carbon	2,720	26-VII-2020	NA				
Turpin Reservoir	Carbon	2,869	26-VII-2020	NA				
Murky Lake	Carbon	2,703	01-VIII-2020	17.2	8.7	0	0.0245	21

Lily pond, SW Long Lake	Carbon	2,710	01-VIII-2020	NA				
Long Lake	Carbon	2,725	01-VIII-2020	35.2	8.5	0	0.0223	17.8
Sand Lake	Carbon	3,091	01-VIII-2020	20.9	9.3	0	0.0138	19.8
Lily pond, 0.43 Mi. SW of Firebox Lake	Carbon	2,960	01-VIII-2020	NA				
Firebox Lake	Carbon	2,931	01-VIII-2020	42.1	8.3	0	0.0325	19.1
Lily pond, FS 105, 0.15 Mi S. of FS104	Carbon	2,765	02-VIII-2020	NA				
Crater Lake	Carbon	2,950	02-VIII-2020	50.1	8.3	0	0.0333	17.4
Silver Lake	Carbon	3,153	07-VIII-2020	35.1	8.5		0.0621	19.1
North Twin lake (Ryan Brothers Lake)	Carbon	3,178	07-VIII-2020	18.7	8	0	0.0121	17.8
South Twin Lake	Carbon	3,142	07-VIII-2020	26.7	8	0	0.0176	20.3
North Banner Lake	Carbon	3,029	16-VIII-2020	18.3	8	0	0.0132	17.5
South Banner Lake	Carbon	3,043	16-VIII-2020	15.8	8.1	0	0.0110	17.1
East Banner Lake	Carbon	3,068	16-VIII-2020	16	8.2	0	0.0106	17.3
Lily pond, 0.43 Mi. SW of Firebox Lake	Carbon	2,960	01-VIII-2020	NA				
Turpin Reservoir	Carbon	2,869	16-VIII-2020	NA				
Lake Marie	Carbon	3,198	16-VIII-2020	13.9	8.5	0	0.0092	15.9
Hanging Lake	Albany	2,770	10-VII-2021	234.1	8.9	0.1	0.1504	18.8
Mirror Lake	Albany	3,217	10-VII-2021	56.1	8.7	0.0	0.0132	14.0
Broklyn Lake	Albany	3,213	10-VII-2021	13.2	8.9	0.0	0.0132	16.8
Lewis Lake	Albany	2,279	10-VII-2021	124.1	7.5	0.0	0.0262	14.2
Highway 130 Lake	Albany	3,196	10-VII-2021	184.7	8.9	0.1	.01181	18.1
Hourglass Lake	Albany	3,202	10-VII-2021	165.2	9.1	0.1	0.1057	19.4
Towner Lake	Albany	3,195	10-VII-2021	90.5	7.3	15.2	0.0632	17.9
Hanging Lake*	Albany	2,770	18-VII-2021	285.2	8.9	0.1	0.1532	19.2
Turpin Reservoir	Carbon	2,869	18-VII-2021	NA				
Long Lake	Carbon	2,725	18-VII-2021	29.3	8.6	0.0	0.0212	16.2
Silver Lake	Carbon	3,153	18-VII-2021	24.2	8.7	0.0	0.0129	14.2

Table 2.2. Environmental variables and sources considered for *Somatochlora hudsonica* and MaxEnt models.

Code	Environmental Variable	Source
BIO1	Annual Mean Temperature 1970-2000 (°C)	Worldclim
BIO2	Mean Diurnal Range Mean of monthly (max temp-min temp) 1970-2000 (°C)	Worldclim
BIO3	Isothermality (BIO2/BIO7) (* 100) 1970-2000 (%)	Worldclim
BIO4	Temperature Seasonality (standard deviation *100) 1970-2000 (°C*100)	Worldclim
BIO5	Max Temperature of Warmest Month 1970-2000 (°C)	Worldclim
BIO6	Min Temperature of Coldest Month 1970-2000 (°C)	Worldclim
BIO7	Temperature Annual Range (BIO5-BIO6) 1970-2000 (°C)	Worldclim
BIO8	Mean Temperature of Wettest Quarter 1970-2000 (°C)	Worldclim
BIO9	Mean Temperature of Driest Quarter 1970-2000 (°C)	Worldclim
BIO10	Mean Temperature of Warmest Quarter 1970-2000 (°C)	Worldclim
BIO11	Mean Temperature of Coldest Quarter 1970-2000 (°C)	Worldclim
BIO12	Annual Precipitation 1970-2000 (mm)	Worldclim
BIO13	Precipitation of Wettest Month 1970-2000 (mm)	Worldclim
BIO14	Precipitation of Driest Month 1970-2000 (mm)	Worldclim
BIO15	Precipitation Seasonality 1970-2000 (Coefficient of Variation) (%)	Worldclim
BIO16	Precipitation of Wettest Quarter 1970-2000 (mm)	Worldclim
BIO17	Precipitation of Driest Quarter 1970-2000 (mm)	Worldclim
BIO18	Precipitation of Warmest Quarter 1970-2000 (mm)	Worldclim
BIO19	Precipitation of Coldest Quarter 1970-2000 (mm)	Worldclim
LCtype	Land cover	NLCD2016
mdLC	Minimum distance to trees cover	Al Mousa 2021

Table 2.3. MaxEnt Model summary for the Hudsonian Emerald dragonfly in the montane and alpine lakes of Northcentral Colorado and southern Wyoming, USA.

Model strategy	Environmental variables	Final variables	AUC_{mean}	$AUC_{training}$	AUC_{test}	$AUC_{training}$ - AUC_{test}	Variable contribution
#1	All variables with Stepwise removal of highly correlated variables	Bio_1 Bio_4 Bio_8 Bio_15 Bio_17 Bio_18 LC	0.951	0.958	0.951	0.004	Bio_4: 28.7 Bio_8: 17.9 Bio_18: 15.8 Bio_17: 15.1 Bio_15: 13.5 LC: 7.3 Bio_1: 1.7
#2	All variables with Stepwise removal of least contribution variables	Bio_1 Bio_4 Bio_10 Bio_15 Bio_17 Bio_18 Bio_19	0.938	0.955	0.938	0.17	Bio_4: 37.0 Bio_18:21.4 Bio_15: 13.3 Bio_17: 12.3 Bio_1: 12.1 Bio_19: 2.0 Bio_10: 1.9
#3	Previously determined variables following Bush et al. (2014a)	Bio_4 Bio_1 Bio_6 Bio_15 Bio_16 Bio17	0.935	0.953	0.935	0.018	Bio_4: 40.9 Bio_17: 22.4 Bio_1: 11.9 Bio_6: 11.8 Bio_15: 11.7 Bio_16: 1.3
#4	Previously determined variables following Sandall and Deans (2018) + Land cover	Bio_1 Bio_4 Bio_5 Bio_8 Bio_10 Bio_12 Bio_15 Bio_18 Bio_19 LC	0.95	0.959	0.951	0.008	Bio_4: 25.2 Bio_18: 18.2 Bio_8: 17.2 Bio_15: 14.0 Bio_19: 13.7 LC: 9.3 Bio_1: 1.9

Table 2.4. Binary logistic regression model analysis results for water parameter data and the presence and/or absence of the Hudsonian Emerald dragonfly (SPSS V 27, IPM corp. 2020) in sampled montane and alpine lakes of Northcentral Colorado and southern Wyoming, USA.

Omnibus Tests of Model Coefficients				
		Chi-square	df	Sig.
Step 1	Step	29.74	6	.000
	Block	29.74	6	.000
	Model	29.74	6	.000

Table 2.5. Classification table for the accuracy of water parameters of the sampled lakes in predicting the presence and/or absence of the Hudsonian Emerald dragonfly in the montane and alpine lakes of Northcentral Colorado and southern Wyoming, USA.

Classification table[a]

			Predicted		
	Observed		presence		Percentage correct
			0	1	
Step 1	Presence	0	163	3	98.2
		1	24	1	4.0
	Overall percentage				85.9

a.The cut value is 0.50

Table 2.6. Records of the Hudsonian Emerald, *Somatochlora hudsonica* collected in summer of 2019 and 2020 in Northcentral Colorado and southern Wyoming (all specimens are deposited in the C.P. Gillette Museum of Arthropod Diversity, Colorado State University).

State	County	location	Date	elevation m	specimens
Colorado	Boulder	Red Rock L., W. of Ward	17-VII-2019	3,100	4♂ 3♀
	Boulder	Rainbow Lakes, lower	23-VII-2019	3,100	7♂
	Boulder	Rainbow Lakes, middle	23-VII-2019	3,111	6♂ 3♀
	Boulder	Red Rock L., W. of Ward	20-VIII-2019	3,100	1♂
	Boulder	Red Rock L., W. of Ward	04-VIII-2020	3,100	3♂
	Boulder	Red Rock L., W. of Ward	07-VIII-2020	3,100	1♂
	Boulder	Red Rock L., W. of Ward	25-VII-2021	3,100	7♂ 1♀
	Boulder	Rainbow Lakes, lower	30-VII-2021	3,098	4♂
	Boulder	Rainbow Lakes, middle	30-VII-2021	3,110	6♂
	Boulder	Rainbow Lakes, upper	30-VII-2021	3,127	4♂
	Boulder	Small lake, W. of Long L.	14-VIII-2021	3,210	1♂
	Gilpin	Forest Lakes, lower	15-VIII-2019	3,245	1♂
	Gilpin	Forest Lakes, middle	15-VIII-2019	3,257	2♂
	Gilpin	Forest Lakes, lower	28-VII-2021	3,245	2♂
	Gilpin	Forest Lakes, middle	28-VII-2021	3,257	2♂
	Gilpin	Forest Lakes, upper	28-VII-2021	3,307	2♂
	Larimer	Lost Lake, Off Rd 103	24-VII-2019	2,835	3♂ 1♀
	Larimer	Laramie Lake, NE of Lost L.	24-VII-2019	2,845	3♂
	Larimer	Twin Lakes, N. of Laramie L.	24-VII-2019	2,866	2♂
	Larimer	Trap Lake, off Long Draw Rd.	30-VII-2019	3,030	12♂ 2♀
	Larimer	Lost Lake, Rawah Wilderness	31-VII-2019	3,100	1♂
	Larimer	Lost Lake, Off Rd 103	07-VII-2020	2,835	2♂
	Larimer	Zimmerman L.	17-VII-2021	3,196	1♂
Wyoming	Albany	Hanging Lake, off Hwy 130	22-VII-2020	2,770	1♂
	Albany	Hanging Lake, off Hwy 130	18-VII-2021	2,770	1♀

Table 2.7. The contribution of each environmental variables in the MaxEnt model for the Hudsonian Emerald dragonfly in Northcentral Colorado and southern Wyoming, USA.

Code	Environmental variable	Percent contribution%	Accumulated contribution percent
Bio_4	Temperature seasonality	28.7	28.7
Bio_8	Mean temperature of wettest quarter	17.9	46.6
Bio_18	Precipitation of warmest quarter	15.8	62.4
Bio_17	Precipitation of driest quarter	15.1	77.5
Bio_15	Precipitation seasonality	13.5	91
LandCover	Tree canopy cover	7.3	98.3
Bio_1	Annual mean temperature	1.7	100

Table 2.8. The suitable range of environmental variables for the potential distribution of the Hudsonian Emerald dragonfly in Northcentral Colorado and southern Wyoming, USA.

Code	Environmental variable	Suitable range	Optimum value
Bio_4	Temperature seasonality (˚C*100)	640-760	680-730
Bio_8	Mean temperature of wettest quarter (˚C)	(-7)-(17)	0-13
Bio_18	Precipitation of warmest quarter (mm)	140-195	150-183
Bio_17	Precipitation of driest quarter (mm)	70-144	80-120
Bio_15	Precipitation seasonality (%)	16-32	18-25
Bio_1	Annual mean temperature (˚C)	0-5	1-4

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CHAPTER THREE: CADDISFLIES (INSECTA: TRICHOPTERA) OF MONTANE AND ALPINE LAKES OF NORTHERN COLORADO (USA)

INTRODUCTION

In the Anthropocene, human activities that destroy and degrade natural habitats are extirpating species at alarming rates, resulting in unprecedented levels of global biodiversity loss (Dirzo et al. 2014). The Intergovernmental Panel on Climate Change (IPCC, 2018) reported that, human activities are estimated to have increased global temperatures by approximately 1.5°C. Climate induced changes to habitats are expected to result in biodiversity loss of plants (Skov and Svenning 2004, Li et al. 2020), amphibians (Yiming et al. 2013), birds (Julliard et al. 2004), spiders (Mammola et al. 2018), insects (Battisti 2004, Hering et al. 2009, Reinemann et al. 2014, Sandin et al. 2014, Lund et al. 2016, Pureswaran et al. 2018, Kellermann and van Heerwaarden 2019, Wagner 2020) and other taxonomic groups (Williams et al. 2015). Extinction risk predictions vary widely, ranging from 0–54% of the earth's species (Thomas et al. 2004, Warren et al. 2013, Urban 2019). Sauer et al. (2011) noted that global climate change will cause huge losses of the biodiversity of alpine regions. Ricciardi and Rasmussen (1999) estimated that the extinction rate of freshwater fauna is higher than that of terrestrial communities and high–altitude ecosystems, especially freshwater habitats, are among the most threatened (Heiskary & Wilson 1989, Houghton 2004). Freshwater ecosystems have experienced temperature and hydrological regime alterations that affect biotic communities (Brown et al. 2007). Many studies have demonstrated that subalpine, alpine, and arctic lakes have been profoundly affected by these environmental changes (Wolfe et al. 2003, Smol et al. 2005, Rühland et al. 2008, Williamson et al. 2008, Hobbs et al. 2010, Reinemann et al. 2014). These environmental changes have had direct effects on aquatic organisms. For example, excess amounts of CO_2 affect oxygen uptake and the formation of carbonic acid causing a decrease in pH (Martins et al. 2017). Additionally, an increase of water temperature above the optimum value decreases leaf consumption and survival rates of many taxa (Boyero et al. 2011). Climate change may affect ecological processes such as leaf decomposition (Martins et al. 2017), and increased wildfires in the high-altitude ecosystems (Calder and Shuman 2017).

Larvae of caddisflies (Trichoptera) occur in almost all types of lotic and lentic habitats at almost all elevations (Wiggins 2004, Holzenthal et al. 2007, Wiggins 2014, Morse et al. 2019). A few species are even known to occur in brackish water and terrestrial ecosystems (Hering et al. 2009, Morse et al. 2019). Caddisflies are integral components of almost all freshwater ecosystems (Wiggins 2004, Morse et al. 2019). Caddisfly larvae have diverse feeding strategies allowing them to play an important role in aquatic ecosystem nutrient cycling (Ross & Wallace 1983, Wiggins 2004). Using silk from salivary glands, and the behavior of building various portable cases, nets, and retreats, larvae occur in habitats not fully exploited by other aquatic insects (Wiggins 2004, Holzenthal et al. 2007, Wiggins 2014, Morse et al. 2019). Caddisflies are considered one of the most important aquatic insect orders as well as a dietary source for insectivorous fish and other animals (Douglas et al. 1983, Kalaninova et al. 2014). Caddisfly larvae are often the most important taxa in regard to nutrient cycling and considered important shredders in both lentic and lotic ecosystems (Wiggins 2004, Wiggins 2014).

Caddisflies are considered among the most sensitive bio-indicators of water quality for both lentic and lotic habitats (Dohet 2002, Holzenthal et al. 2007), and are useful in the assessments of aquatic systems (Hering et al. 2009). Hering et al. (2009) analyzed the sensitivity of 1,134 European caddisflies species to climate change, and they found that endemism, feeding guild, and short emergence are the main drivers for species sensitivity to climate change. Boyero et al. (2011)

indicated that along latitudinal temperature gradients, climate change will increase microorganic activities on leaf breakdown and decrease shredders leaf breakdown, an important feeding guild of caddisfly larvae.

At least 1,507 caddisfly species representing 156 genera in 27 families are known from the Continental United States and Canada (Morse 2020, Rasmussen & Morse 2020). To date, 198 Trichoptera species have been reported from Colorado (Herrmann et al. 1986, Ruiter 1990, Ruiter 1999, Myers & Youghanz 2007, Heinold 2010, Zuellig et al. 2012). However, there is no account of the caddisflies of the montane, and alpine lakes of northern Colorado, except the reporting occurrence records by Yamamoto & Wiggins (1964), Herrmann et al. (1986), Bushnel et al. (1987), Ruiter (1995), Ruiter (1999), Myers & Youghanz (2007), Heinold (2010), and Zuellig et al. (2012).

Our faunistic survey provides new distributional information on high elevation lentic caddisflies from Boulder, Clear Creek, Gilpin, Grand, Jackson, Larimer, and Routt counties in northern Colorado. To our knowledge, our study is the first to document the diversity of caddisflies in the montane and alpine lakes of the above counties, including the presence of vulnerable species (DeWalt et al. 2005). Little information is available about benthic invertebrates of Rocky Mountains unique lentic habitats (Wissinger et al. 1999, Wissinger et al. 2003), despite vulnerabilities that have long been recognized for alpine aquatic ecosystems (Hauer et al. 1997). Existing threats to the invertebrate assemblages of most montane and alpine lakes in Colorado include species assemblage alterations from widespread fish introductions (Baron et al. 2000, Wolfe et al. 2001). Population growth and development of the Colorado Front Range (Veblen and Lorenz 1991) poses additional threats to habitat quality for alpine aquatic invertebrates due to anthropogenic–related atmospheric depositions into sensitive high–elevation aquatic ecosystems (Baron et al. 2000, Wolfe et al. 2001). Further, climate change is likely to accelerate atmospheric depositions and changes in physiochemical water quality in alpine and subalpine aquatic ecosystems (Williams et al. 2002, McGuire et al. 2012, Kittel et al. 2015). Understanding past and current faunal distributions of high–elevation caddisflies throughout northern Colorado provides a valuable basis for determining conservation priorities for alpine aquatic environs and biodiversity.

MATERIALS AND METHODS

Study Area

Caddisfly species occurrences were obtained from field collections and records of past collections across 136 montane and alpine lentic habitats across northern Colorado. Caddisfly adults were either directly collected, reared from larvae, or records were obtained from an available database (formerly maintained by the late David E. Ruiter) or from literature (Yamamoto & Wiggins 1964, Bushnell et al. 1987, Ruiter 1995, Ruiter 1999, Heinold 2010, and Zuellig et al. 2012) from the montane and alpine lakes. These records were of species known to have been collected from Boulder, Clear Creek, Gilpin, Grand, Jackson, Larimer, and Routt counties of northern Colorado, USA (Figs.3 1–3.21). Adults and larvae were sampled from June to September 2019 and June to September 2020. Sampling sites represent a wide range of montane and alpine lakes in northern Colorado. These sites were selected based on their accessibility within the Arapaho and Roosevelt National Forest (ARNF) and the Medicine-Bow & Routt National Forest (MBRNF, Figs. 3.1–3.21). Habitats were classified in accordance with Pennak's (1969) classification of Colorado lakes: montane lakes at an elevation of 2,500 to 3,200 meters above sea level (m), and alpine lakes in elevations above 3,200 m.

Field Collections

I sampled caddisfly adults from a total of 82 montane and alpine lentic habitats across 103 cumulative sampling visits to montane and alpine lakes of Boulder, Clear Creek, Gilpin, Grand, Jackson, Larimer, and Routt counties from June to September 2019 and 2020 (Appendix 3). Adults were collected using aerial nets by sweeping riparian vegetation around each lake and peripheral alpine wetlands directly at the edge of montane and alpine lakes. Wetland habitats with streams and lotic conditions were avoided in order to limit my collections to lentic-associated taxa. All collected adults were placed in labeled vials with 80% ethanol. For taxonomic assessment, adult genitalia were macerated using the lactic acid method of Blahnik et al. (2007) for genitalic examinations. Larval specimens were collected by hand picking or by using D–frame kick net (1–mm mesh), transported in insulated containers, and reared to adults in the laboratory at Colorado State University. Upon emergence, reared adults were preserved in 80% ethanol. Additionally, a portion of larvae were preserved in 80% ethanol to verify the presence of larvae of the genera maintained. Adult caddisflies were identified using Rasmussen & Morse (2018) with nomenclature following Morse (2020) and Rasmussen & Morse (2020). Vouchers for all collected material were deposited in the C.P. Gillette Museum of Arthropod Diversity, Colorado State University (CSUC). Water chemistry parameters (Appendix 3) were taken at each visit from June to September in 2019 and 2020; total dissolved solids (TDS), water temperature, conductivity, salinity, and pH were measured on site during each visit using EcoSense® EC300 portable instrument (www.ysiecosense.com). I present distribution maps for species records for each family in a single map except for the Limnephilidae, where a map was plotted for each species with more than three records. Where distribution records for two species are few, we incorporated these records into a single map. Localities for each species are indicated by a visual symbol placed in front of the species name. Data locality for each species with less than four records are provided in Table 3.3. Most of the records reported herein were adult specimens and only a few records were from larval specimens. ArcGIS 10.7.1 (ESRI) was used to spatially plot coordinate data. Watershed (lake) boundaries, hydrology datasets, and physio-geographic boundaries were obtained from the USGS National Hydrology Dataset (U.S. Geological Survey 2019). Detailed locality records are available from the author.

Review of Published Records

Additionally, caddisfly adult species records were compiled from 93 other unique montane and alpine lentic habitats of these seven counties of northern Colorado from a caddisfly database of Colorado Trichoptera maintained by David E. Ruiter (from 1900 to 2017), and from peer–reviewed literature (Yamamoto & Wiggins 1964, Bushnell et al. 1987, Ruiter 1995, Ruiter 1999, Heinold 2010, Zuellig et al. 2012). Although some listed records from the database and literature were collected by light traps, we included them in our findings because they represented well-known lentic caddisfly species. If species are listed as “collected”, specimens were collected in 2019–2020 by M.A. Al Mousa and B.C. Kondratieff; if indicated “recorded”, specimens’ records are from DER database and literature. All records “collected and recorded” are listed in Appendix 4.

RESULTS AND DISCUSSION

A total of 541 species records of montane and alpine lentic caddisfly were compiled and mapped from field collections, collected records maintained by the late David E. Ruiter, and from peer reviewed literature (Yamamoto & Wiggins 1964, Herrmann et al. 1986, Bushnell et al. 1987, Ruiter 1995, Heinold 2010, Zuellig et al. 2012). These records are presented in Figs 3.1–3.21, Tables 3.1–3.3 and Appendix 4. Records for species with fewer than four locality records are listed in Table 3.3.

Forty-nine species of caddisflies representing 24% of all known caddisfly species of Colorado were recorded in this study. All 49 species are considered lentic, representing 24 genera in seven families (Tables 3.1 & 3.2). The Limnephilidae had the highest number of recorded species with 37 species representing 12 genera (76% of species), including 21 species of the Holarctic genus *Limnephilus* (43% of species). Apataniidae and Polycentropodidae had the lowest species richness and distribution, with only one species of each family recorded from two lentic habitats. both of *Apatania zonella* **(**Zetterstedt, 1840) and *Polycentropus aureolus* (Banks) 1930 recorded from two localities in the study area. The family Molannidae was represented only by one species, *Molanna flavicornis* Banks 1914 collected from 14 montane and alpine lakes from the seven counties (Table 3.1, Appendix 4).

During this study no new state species records were discovered but numerous new county records were documented. For example, *Agrypnia glacialis* (Hagen, 1873) was collected for the first time from Grand and Larimer Counties high elevation lakes; *Asynarchus montanus* (Banks) 1907 in Boulder, Gilpin, and Larimer Counties; *Lenarchus fautini* (Denning, 1949) from Boulder County; and *Molanna flavicornis* Banks 1914 from Jackson County.

Water quality data for the 82 montane and alpine lakes sampled in this study varied considerably and is presented in Appendix 4 for future comparative studies. These lakes have relatively small surface area. Water pH readings were generally neutral to slightly alkaline for most of the lakes, ranging from 6.9–9.6 in 2019 and from 6.5–9.6 in 2020 sampling events, similar to regional norms (Musselman and Slauson 2004). Conductivity ranged widely from 10.5–73.7 microsiemens per centimeter (uS/cm) in 2019 and from 7.0–208.1 uS/cm in 2020, similar to regional norms (Musselman and Slauson 2004). Water temperature taken at the lakes from June through September ranged from 6.2–21.4˚C in 2019 and from 3.6–20.4˚C in 2020. Salinity was almost zero ppm in all the sampled lakes since many lakes are fed by snow melt. Total Dissolved Solids (TDS) values were usually below 0.1200 ppm, ranging from 0.0074–0.0487 ppm in 2019 and from 0.0046–0.1058 ppm in 2020 (Appendix 3), similar to regional norms (Musselman and Slauson 2004).

Family Apataniidae

Apataniidae were relatively poorly represented. Of the 32 species of the Early Smoky Wing Sedges that are known from the continental United States and Canada (Rasmussen & Morse 2018), only one lentic species was recorded from northern Colorado. The Holarctic *Apatania zonella* (Zetterstedt, 1840) was recorded from Chasm Lake in Larimer County and Summit Lake in Clear Creek County at an elevation of 3,750–3,915m between 1996 and 2015 (Fig. 3.1, Tables 3.1 & 3.3, Appendix 4).

Family Hydroptilidae

The purse-case caddisflies or the micro-caddisflies is the largest caddisfly family with more than 2,000 species worldwide, represented by at least 309 species in the continental United States and Canada (Rasmussen & Morse 2018), and at least 27 species in Colorado (Herrmman et al. 1986 and Zuellig et al. 2012). Two hydroptilid species of two genera were recorded from high elevation lentic habitats of northern Colorado. The Holarctic *Agraylea multipunctata* Curtis, 1834, a common species in rivers, ponds, and lakes (Zuellig et al. 2012) is widely distributed across northern North America and was recorded from six high elevation lakes in Boulder (1 location), Gilpin (2), Larimer (2), and Routt (1) Counties between 1982 and 2016 (Fig. 3.2, Table 3.1, Appendix 4) with an elevation range of 2,485–3,100m. The genus *Oxyethira* was represented by one species, *Oxyethira dualis* Morton 1905 recorded from a wetland in 1981 at the edge of Red Rock Lake, Boulder County at an elevation of 3,100m (Fig. 3.2, Tables 3.1 & 3.3, Appendix 4).

Family Leptoceridae

The family Leptoceridae or the long–horned caddisflies with more than 1,500 species is the second largest caddisfly family (Morse 2020). In North America, 123 species of Leptoceridae have been reported (Rasmussen & Morse 2018). Three leptocerid species are recorded from northern Colorado montane and alpine lentic habitats. The Holarctic *Mystacides interjecta* (Bank, 1914) was recorded and collected from 11 lakes in Boulder (2 lakes), Gilpin (2), Grand (2), Jackson (1), and Larimer (4) Counties from 1939 to 2020 at an elevation range of 2,550–3,200m. *Mystacides longicornis* (Linnaeus, 1758) was recorded from Sheep Lake, RMNP, Larimer County in 1939. The geographically widespread and common caddisfly, the Plain Red-Brown Long Horn Sedge *Oecetis inconspicua* (Walker, 1852) was recorded from two locations in Boulder and Larimer counties at an elevation range of 2,835–3,100m in the years 1994 and 1995 (Fig. 3.3, Tables 3.1 & 3.3, Appendix 4).

Family Limnephilidae

At least 37 species (76% of recorded species during this study) of Limnephilidae (the northern case making caddisflies) occurred commonly in both montane and alpine lakes. Of these 37 species, 21 (almost 43% of recorded species) are species of the large and widespread genus *Limnephilus* (Figs. 3.4–3.18, Tables 3.2 & 3.3, Appendix 4). The Holarctic *L. abbreviatus* Banks 1908, a common regional species (Ruiter 1995), was the most frequently recorded and collected lentic species, taken at 33 northern Colorado lakes and associated wetlands from 1925 to 2020 (Fig. 3.4, Appendix 4) in Boulder (7), Clear Creek (1), Gilpin (1), Grand (8), Jackson (2), Larimer (13), and Routt (1) Counties, at an elevation range from 2,550–3,550m. The Holarctic *L. picturatus* MacLachlan, 1875, known as the Painted Northern Caddisfly, was recorded and collected from 29 lakes from 1924 to 2020 (Fig. 3.5, Appendix 4) in Boulder (6), Clear Creek (3), Grand (4), Jackson (1), and Larimer (15) Counties from an elevation range of 2,740–3,360 m. *Asynarchus nigriculus*

(Banks, 1908) was collected and recorded between 1934 and 2020 from 28 lentic localities (Fig. 3.6, Appendix 4) with an elevation range of 2,545–3,695m in Boulder (14), Clear Creek (3), Gilpin (1), Grand (1), Jackson (2), and Larimer (7) Counties. Wiggins (2014) noted that they collected larvae of this species in streams, ponds, and temporary ponds. The type locality of this species is Clear Creek County, Colorado (Rasmussen & Morse 2018). In a study of the caddisflies of the high-elevation lentic habitats in Colorado, Wissinger et al. (2003) noted that *A. nigriculus* was the most abundant species in both high-elevation autumnal habitats and vernal ponds. Four species of the Nearctic genus *Hesperophylax* Banks, 1916 were recorded in this study. Species of this genus usually inhabit lotic habitats but can occur in cold springs and lakes where they inhabit shallow water (Parker and Wiggins 1985, Wiggins 2014). The Nearctic *H. occidentalis* (Banks, 1908) was recorded and collected from 21 locations between 1980 and 2020 (Fig. 3.7, Appendix 4) in Boulder (7), Clear Creek (1), Grand (7), Jackson (1), and Larimer (5) Counties lentic habitats from an elevation range of 2,545–3,565m. Bushnell et al. (1987) collected larvae of this species from five localities (Green Lakes and Albion Lake) in Boulder County. Wissinger et al. (2003) also listed this species from permanent high elevation lakes in Colorado. The Holarctic *Limnephilus externus* Hagen, 1861 was recorded and collected from 19 lakes between 1979 and 2020 (Fig. 3.8, Appendix 4) at elevation range of 2,510–3,155m in Boulder (5), Grand (6), Jackson (1), Larimer (6), and Routt (1) Counties. Wissinger et al. (2003) consider this species as the most abundant species in Colorado permanent ponds. *Limnephilus janus* Ross 1938 was collected and recorded between 1924 and 2020 from 14 locations (Fig. 3.9, Appendix 4) in Boulder (4), Gilpin (1), Grand (1), Jackson (2), Larimer (4), and Routt (1) Counties, with an elevation range from 2,510–3,210 m. *Limnephilus coloradensis* (Banks) 1899 was recorded and collected from 13 lakes from the year 1925 to 2020 (Fig. 3.10, Appendix 4) in Boulder (3), Grand (2), Jackson (1), and Larimer (7) counties at an elevation of 2,795–3,345m. *Anabolia bimaculata* (Walker, 1852) was recorded from 12 lentic habitats between 1960 and 1997 (Fig. 3.11, Appendix 4) in Boulder (1), Gilpin (1), Grand (3), Larimer (5), and Routt (2) Counties, from an elevation range of 2,510–3,255m.

Three limnephilid species were reported each from 11 locations; *Glyphopsyche irrorata* (Fabricius, 1781) a species usually considered lotic (Wiggins 2014), was recorded from in Boulder (5), Gilpin (1), and Larimer (5) counties, from an elevation of 2,500–2,231m between 1977 and 1999 (Fig. 3.12, Appendix 4); *L. indivisus* Walker 1852 was recorded and collected between 1923 and 2019 from Boulder (1), Grand (2), Jackson (1), and Larimer (7) counties at an elevation of 2,580 to 3,155m (Fig. 3.13, Appendix 4); *L. moestus* Banks 1908 was recorded and collected from in Boulder (3), Grand (4), and Larimer (3) Counties at an elevation ranged from 2,580 to 3,262m from 1938 to 2020 (Fig. 13, Appendix 2).

Psychoglypha subborealis Banks, 1924, a lotic species that occurs in spring runs, streams, and pools (Wiggins 2014) was recorded from 10 locations (Fig. 3.14, Appendix 4), in Boulder (4), and Larimer (6) Counties, from an elevation of 2,500–3,430m from 1981 to 1998. *Dicosmoecus atripes* (Hagen, 1875) a lotic species but larvae can be found along lakes shores (Wiggnis 2014), was recorded from nine lakes between 1953 and 1999 (Fig. 3.15, Appendix 4) in Boulder (3), Clear Creek (2), and Larimer (4) Counties, at an elevation 2,570–3,705m. *Asynarchus montanus* was recorded and collected from eight locations between 1994 and 2019 (Fig. 3.6, Appendix 4), in Boulder (1), Gilpin (1), Grand (5), and Larimer (1) Counties, from an elevation of 2,650–3,345m. *Hesperophylax designatus* (Walker, 1852) was recorded from eight locations between 1954 and 1997 (Fig. 3.7, Appendix 4), in Clear Creek (1), Gilpin (1), Grand (2), and Larimer (4) Counties, from an elevation range of 2,550–3,635m. *Limnephilus hyalinus* Hagen, 1861 was recorded and collected also from eight lakes between 1934 and 2020 (Fig. 3.16, Appendix 4) from four counties;

Boulder (1), Grand (3), Jackson (1) and Larimer (3) Counties, from an elevation of 2,540–3,100m. *Nemotaulius hostilis* (Hagen, 1873) was recorded from six lentic habitats at an elevation range of 2,670–3,210m from 1977 to 2006, in Boulder (3), Grand (1), and Larimer (2) Counties (Fig. 3.17, Appendix 4). *Psychoronia costalis* Banks (1901, 1873) was recorded only in the year 1981 from five localities in Boulder county, at an elevation range of 3,355–3,565m (Fig. 3.17, Appendix 4). *Limnephilus sublunatus* Provancher 1877 was also collected and recorded from five lakes at elevation range of 2,550–2,918m between 1924 and 2020 in Grand (2), and Larimer (3) Counties (Fig. 3.18, Appendix 4). *Limnephilus castor* Ross & Merkley, 1952 was recorded from four lakes from 1990 to 2000 (Fig. 3.16, Appendix 4) in Grand (1), Larimer (2), and Routt (1) counties, at an elevation of 2,550–2,830m. *Limnephilus diversus* Hagen, 1861 was recorded from four locations in Boulder (1), Gilpin (1), and Larimer (2) Counties at elevation ranges between 2,585 and 3,360m from 1990 to 2015 (Fig. 3.18, Appendix 4).

Eight limnephilid species were recorded or collected from single lentic sites (Table 3.3, Appendix 4): *Grammotaulius loretta* Denning, 1941 (Lost Lake, Larimer County) in 1995; *Lenarchus (Paralenarchus) brevipennis* (Banks, 1899), (Twin Lakes, Larimer County) in 2019; *Limnephilus dispar* McLachlan, 1875 (wetland, west of Red Rock Lake, Boulder County) between 1982 and 2003; *L. perpusillus* Walker, 1852 (wetland, west of Red Rock Lake, Boulder County) from 1981 to 2003; *L. productus* Banks, 1914 (Rangers Meadows, Shadow Mountain Dam, Grand County) in 1995; *L. rhombicus* (Linnaeus 1758) (pond FS 100, off Co. Rd. 15, Grand County) in 2014; *L. tarsalis* (Banks, 1920), from Red Rock Lake, Boulder County, no date was provided; and *L. thorus* Ross, 1938 was collected in 1949 (Rocky Mountain National Park, Larimer County).

Family Molannidae

One species of the hooded casemaker caddisflies; *Molanna flavicornis* Banks, 1914 was collected and recorded from 14 lakes between 1933 and 2020 in four counties of the study area, Boulder (5), Clear Creek (1), Gilpin (2), Jackson (1) and Larimer (5) Counties at elevation between 2,675–3,240m (Fig. 3.19, Table 3.1, Appendix 4).

Family Phryganeidae

Twenty–eight Phryganeidae (the giant casemakers) species are known to occur in North America (Wiggins 1998, Rasmussen & Morse 2018) and known to inhabit large and permanent lentic habitats (Wiggins 2014, Wissinger et al. 2003). Herrmman et al. (1986) and Zuellig et al. (2012) documented five species of this family in Colorado. Four species are recorded from the montane and alpine lakes of the study area. *Agrypnia deflata* (Milne, 1931) was recorded from three localities between 1984 and 2008 in Boulder (2), and Larimer (1) counties, from an elevation range of 2,835–3,200m; *Agrypnia glacialis* was recorded in 1999 from Trap Lake (Larimer County) and we collected it in 2019 from Stone Lake (Grand County) at an elevation range of 3,030–3,240m. *Agrypnia straminea* Hagen, 1973 was recorded from three lakes between 1983 and 1996 in Jackson (2) and Larimer (1) Counties at an elevation range of 2,765–3,275m. *Phryganea cinerea* Walker 1852 was recorded from one lake in each of the counties of Boulder, Jackson, and Larimer at an elevation range of 2,565–3,100m between 1982 and 2011(Fig. 3.20, Tables 3.1 & 3.3, Appendix 4).

Family Polycentropodidae

Polycentropodidae (trumpet–net and tube–making caddisflies) are an uncommon family in Colorado (Herrmann et al. 1986). One species, *Polycentropus aureolus* was recorded from two localities in 1995 at an elevation of 2,650–2,835m from one lake in Grand County and one in Larimer County (Fig. 3.21, Tables 3.1 & 3.3, Appendix 4).

SUMMARY

The montane and alpine lakes of Larimer and Boulder counties had the highest caddisfly species richness with 38 and 34 species, respectively. This was expected because there were more opportunities to sample the lakes, and the lakes were relatively more accessible. Grand County had 25 species; Jackson County had 14 species; Gilpin County recorded 11 species; Clear Creek had eight species, and Routt counties had seven species (Appendix 4, Tables 3.1 & 3.2).

Of the 49 recorded species of the study, three species are known only from alpine lakes, 23 species recorded from montane lakes, and 23 species from both montane and alpine lakes (Appendix 4, Tables 3.1, 3.2 & 3.3). Caddisflies of the shallow alpine lakes will be probably the most affected by climate changes because of water temperature impacts (Čiamporová-Zaťovičová et al. 2010).

In summary, this study presents the first review of the caddisfly species of accessible montane lakes (2,500–3,200m) and alpine lakes (above 3,200m) of northern Colorado. The majority of these records were collected before the year 2000. No additional records for twenty-two species are available since the year 2000, and 13 of those species are known from three locality records or less. Two species were recorded for the first time after 2000 (Appendix 4), *Lenarchus brevipennis* (Banks, 1899) collected from a drainage along Twin Lake Trail, Larimer County by B.C. Kondratieff & M.A. Al Mousa, 24–VII–2019; *Limnephilus rhombicus* (Linnaeus) 1758 collected from a pond, off Co Rd 15, FS 100, Grand County by (B.C. Kondratieff, 07–VIII–2014). Two species have only one single record, and it was dated prior the year 1950 (Appendix 4), Limnephilus *thorus* Ross, 1938, collected from Rocky Mountain National Park by R.W. Fredrickson, 23–VIII–1949; *Mystacides longicornis* (Linnaeus, 1758) collected from Sheep Lake (RMNP), Larimer County in 17–VII–1939. My findings document the need to continue sampling the high–elevation lentic habitats to see if these previously unreported taxa still occur at these sites.

Those lakes are crucial ecosystems that are or will be impacted by climate change. Knowledge of the fauna of these ecosystem gems is important to predict future faunal changes. Many of the species documented during this study are considered Holarctic, another potentially useful indicator of global climate changes. I suggest that state and regional surveys be coupled with greater protection and conservation considerations of vulnerable montane and alpine aquatic habitats. To conserve rare invertebrates, I also recommend that fisheries managers strongly consider rare and vulnerable invertebrate taxa, such as the alpine Trichoptera presented herein, when determining suitable locations for stocking salmonids.

FIGURES AND TABLES

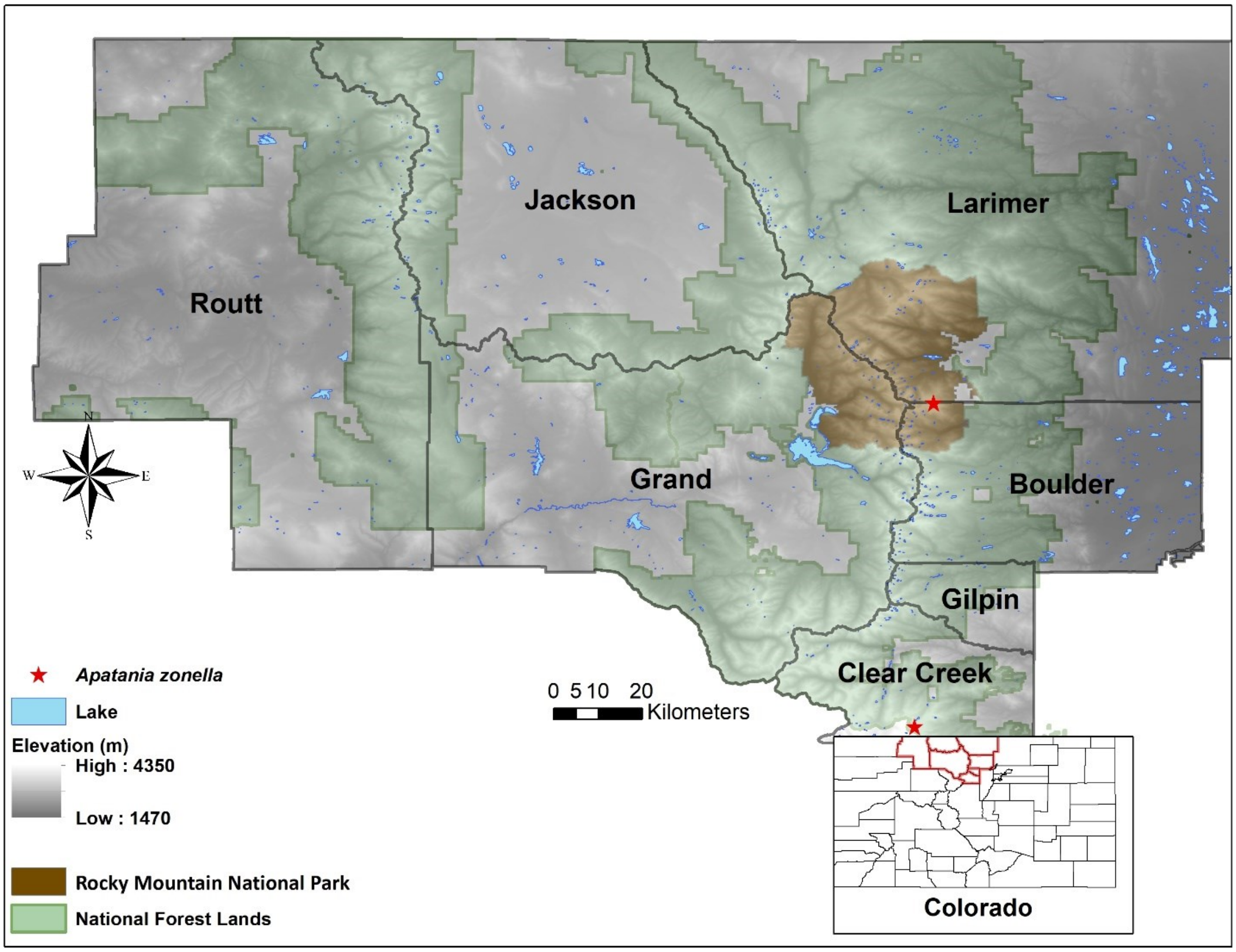

Figure 3.1. Distribution records of Apataniidae (Trichoptera) in montane and alpine lakes of Boulder, Clear Creek, Gilpin, Grand, Jackson, Larimer, and Routt Counties, northern Colorado, USA. Not all lakes are indicated on the maps because of their small size.

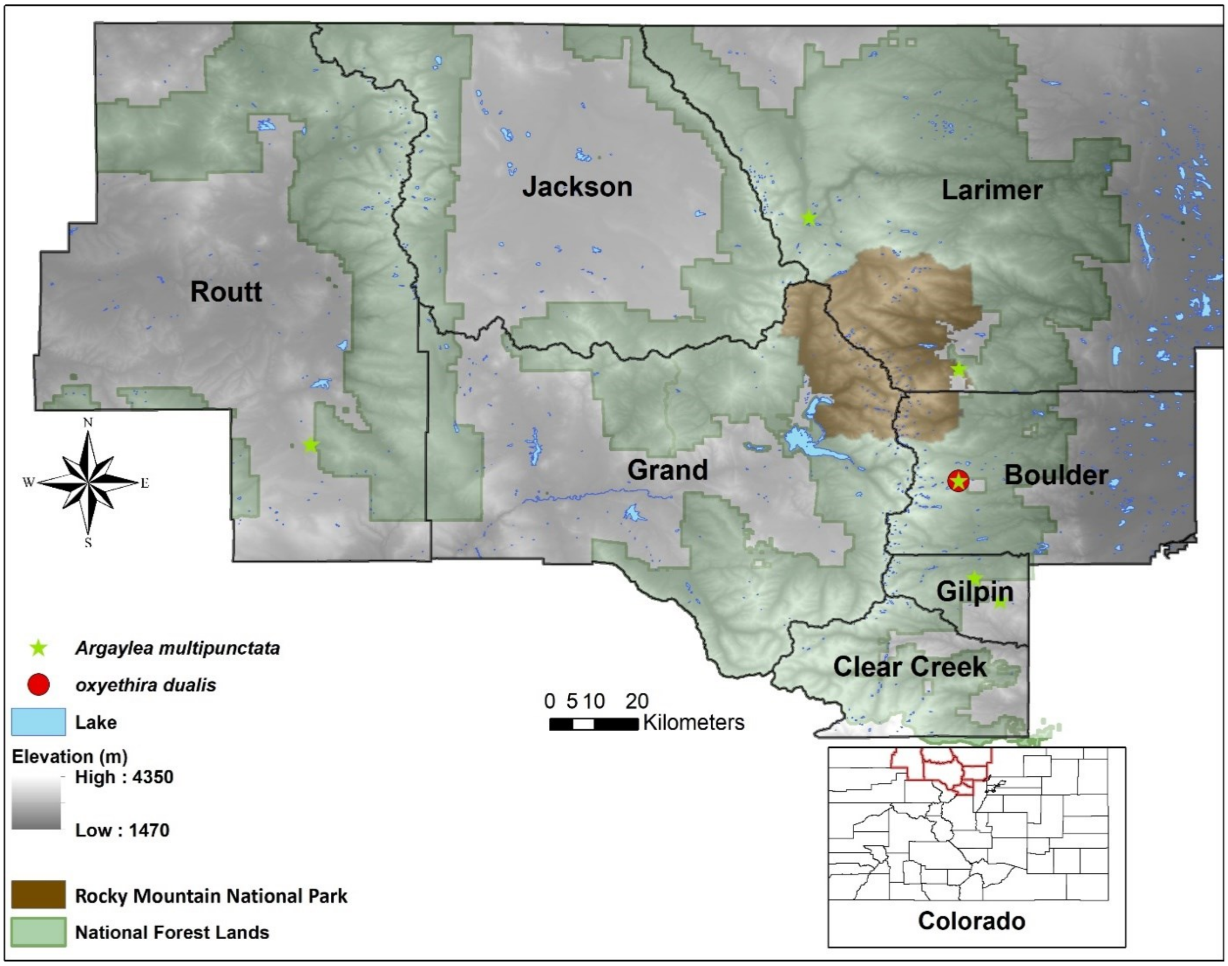

Figure 3.2. Distribution records of Hydroptilidae (Trichoptera) in montane and alpine lakes of Boulder, Clear Creek, Gilpin, Grand, Jackson, Larimer, and Routt Counties, northern Colorado, USA.

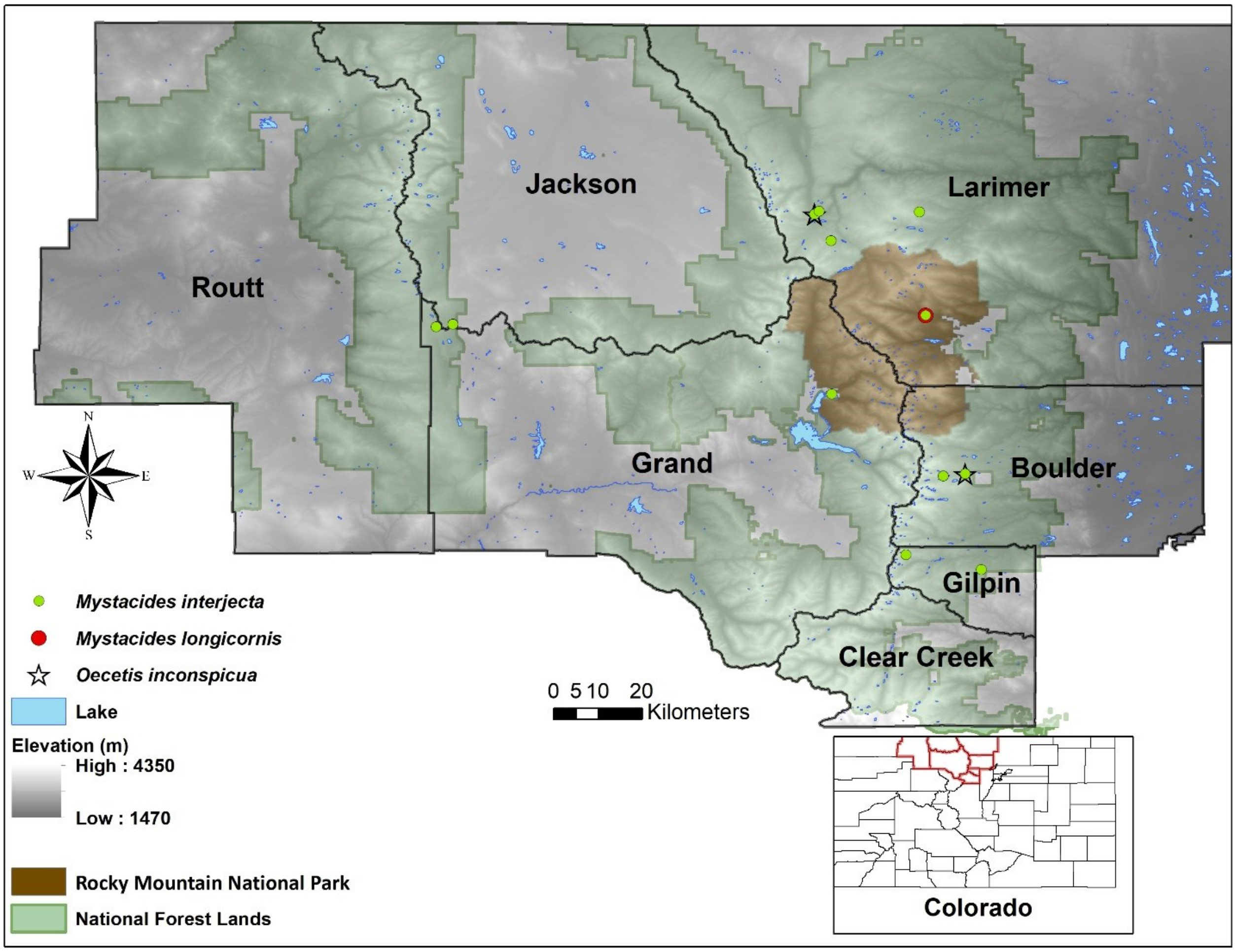

Figure 3.3. Distribution records of Leptoceridae (Trichoptera) in montane and alpine lakes of Boulder, Clear Creek, Gilpin, Grand, Jackson, Larimer, and Routt Counties, northern Colorado, USA.

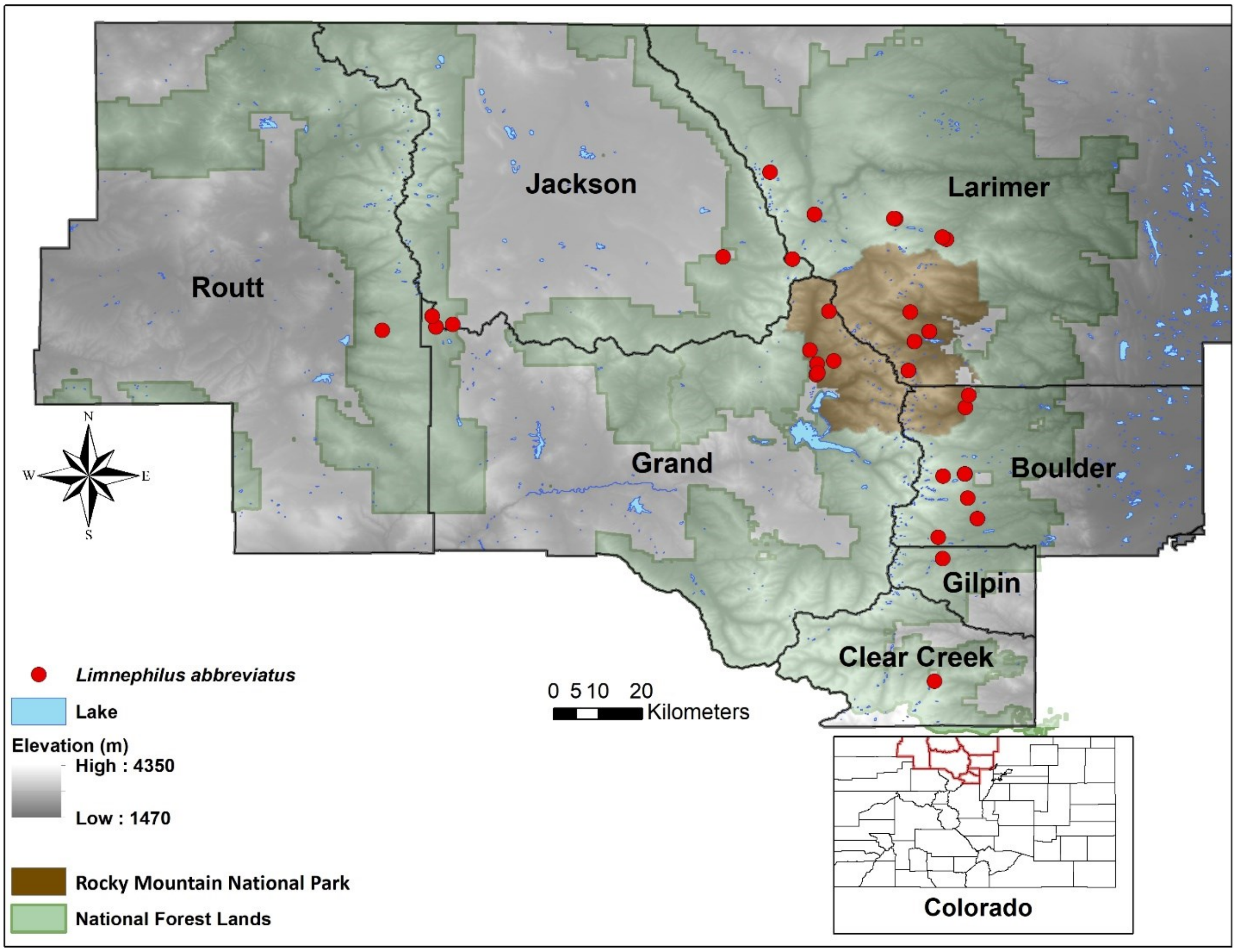

Figure 3.4. Distribution records of *Limnephilus abbreviatus* (Limnephilidae: Trichoptera) in montane and alpine lakes of Boulder, Clear Creek, Gilpin, Grand, Jackson, Larimer, and Routt Counties, northern Colorado, USA.

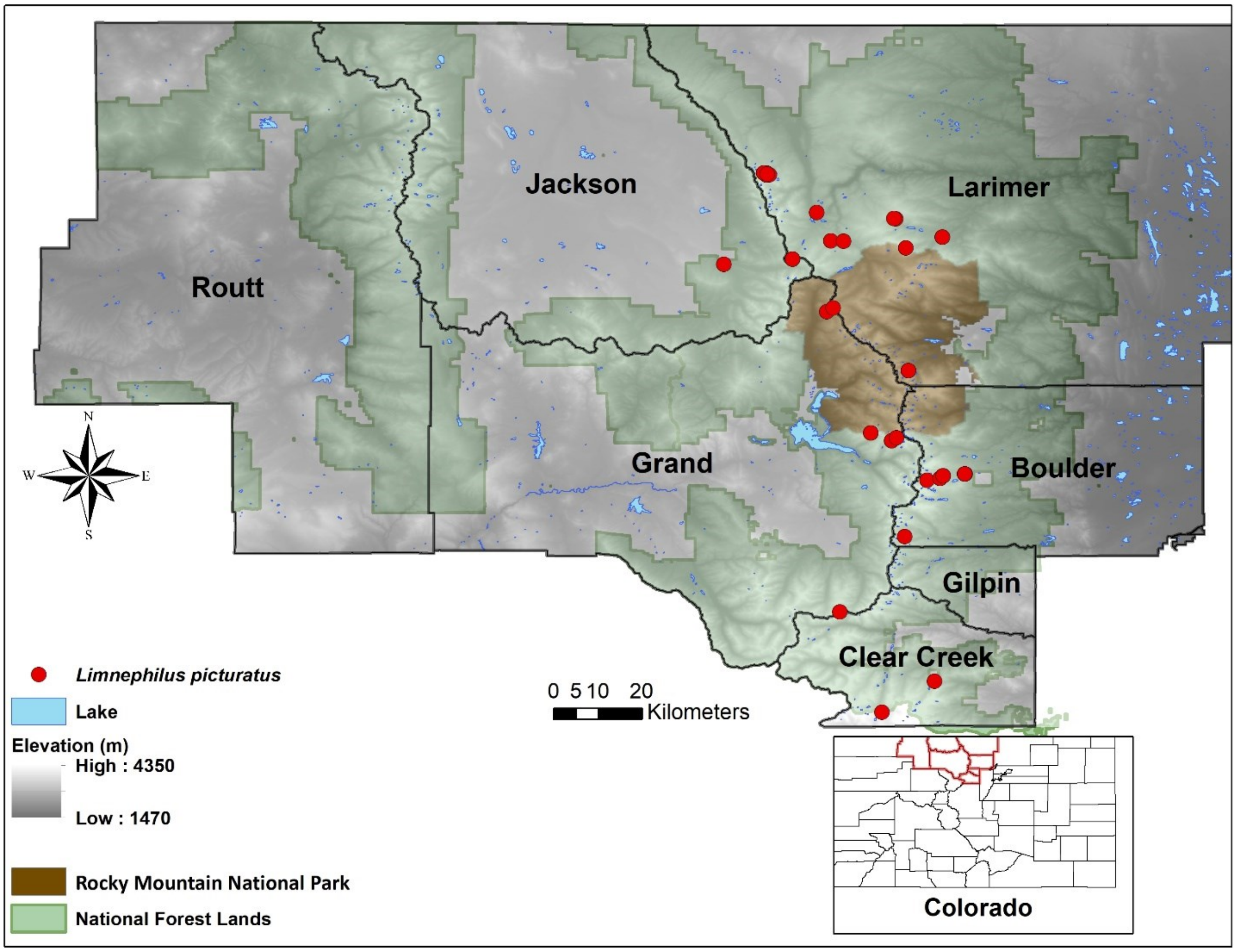

Figure 3.5. Distribution records of *Limnephilus picturatus* (Limnephilidae: Trichoptera) in montane and alpine lakes of Boulder, Clear Creek, Gilpin, Grand, Jackson, Larimer, and Routt Counties, northern Colorado, USA.

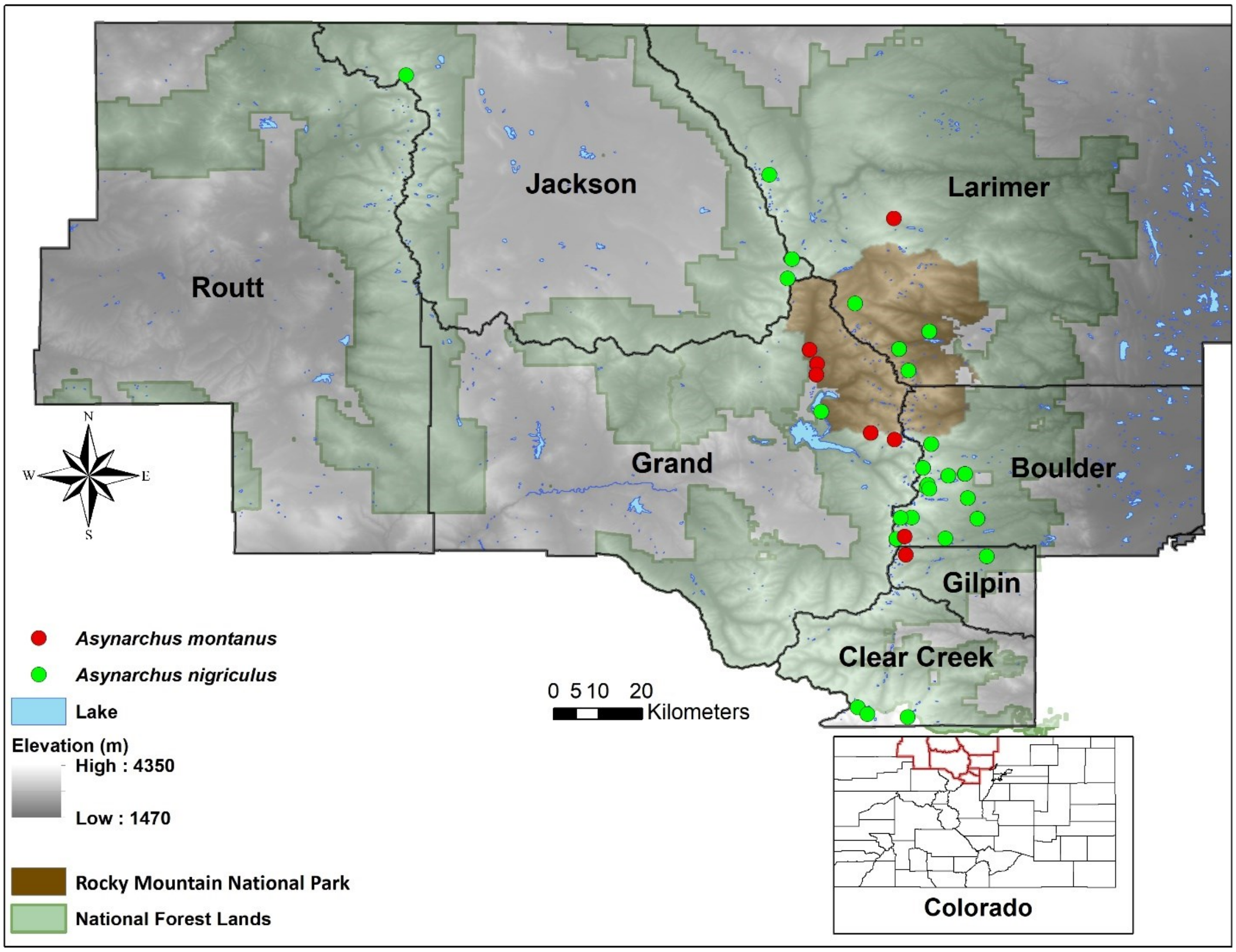

Figure 3.6. Distribution records of the genus *Asynarchus* (Limnephilidae: Trichoptera) in montane and alpine lakes of Boulder, Clear Creek, Gilpin, Grand, Jackson, Larimer, and Routt Counties, northern Colorado, USA.

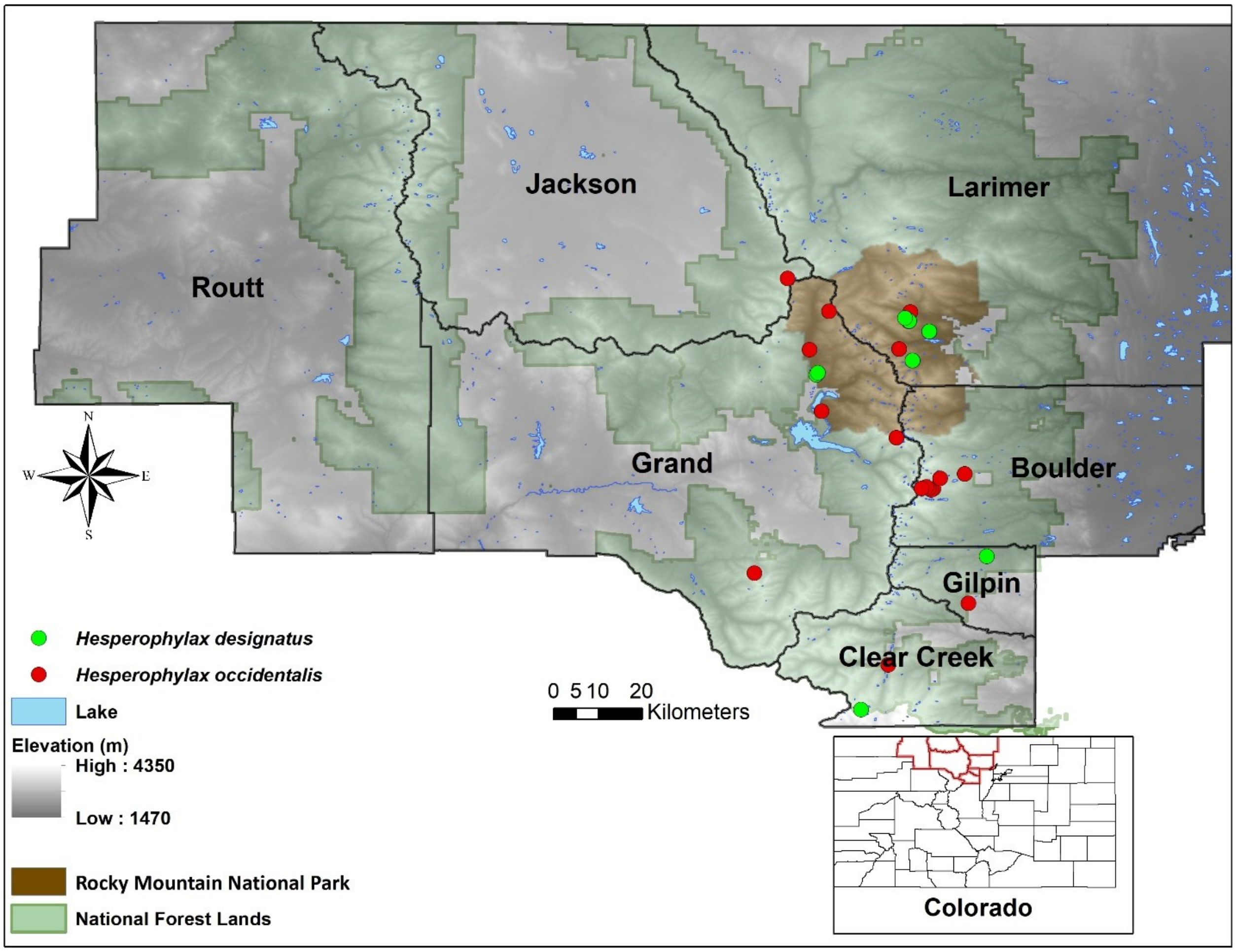

Figure 3.7. Distribution records of *Hesperophylax designatus* and *Hesperophylax occidentalis* (Limnephilidae: Trichoptera) in montane and alpine lakes of Boulder, Clear Creek, Gilpin, Grand, Jackson, Larimer, and Routt Counties, northern Colorado, USA.

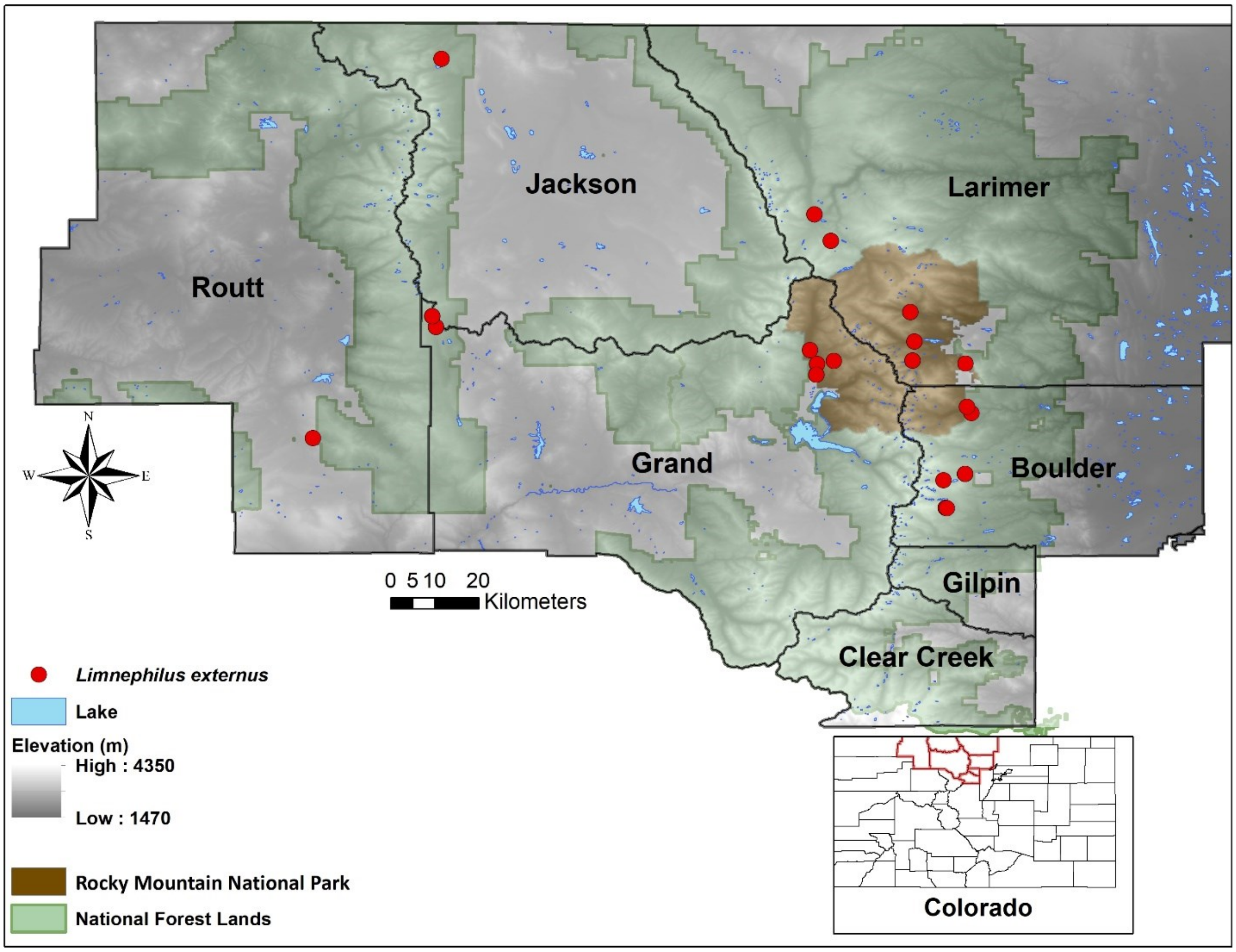

Figure 3.8. Distribution records of *Limnephilus externus* (Limnephilidae: Trichoptera) in montane and alpine lakes of Boulder, Clear Creek, Gilpin, Grand, Jackson, Larimer, and Routt Counties, northern Colorado, USA.

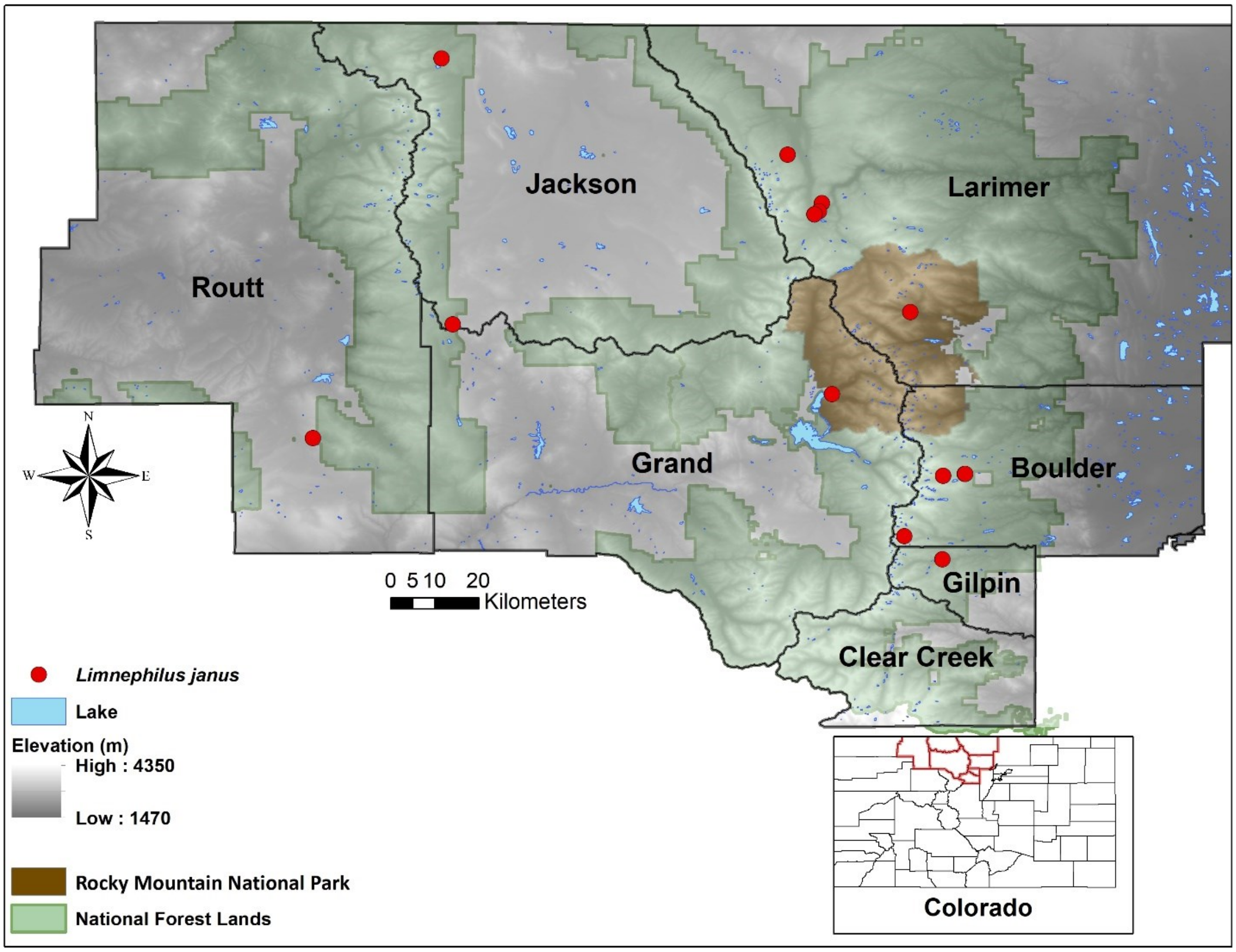

Figure 3.9. Distribution records of *Limnephilus janus* (Limnephilidae: Trichoptera) in montane and alpine lakes of Boulder, Clear Creek, Gilpin, Grand, Jackson, Larimer, and Routt Counties, northern Colorado, USA.

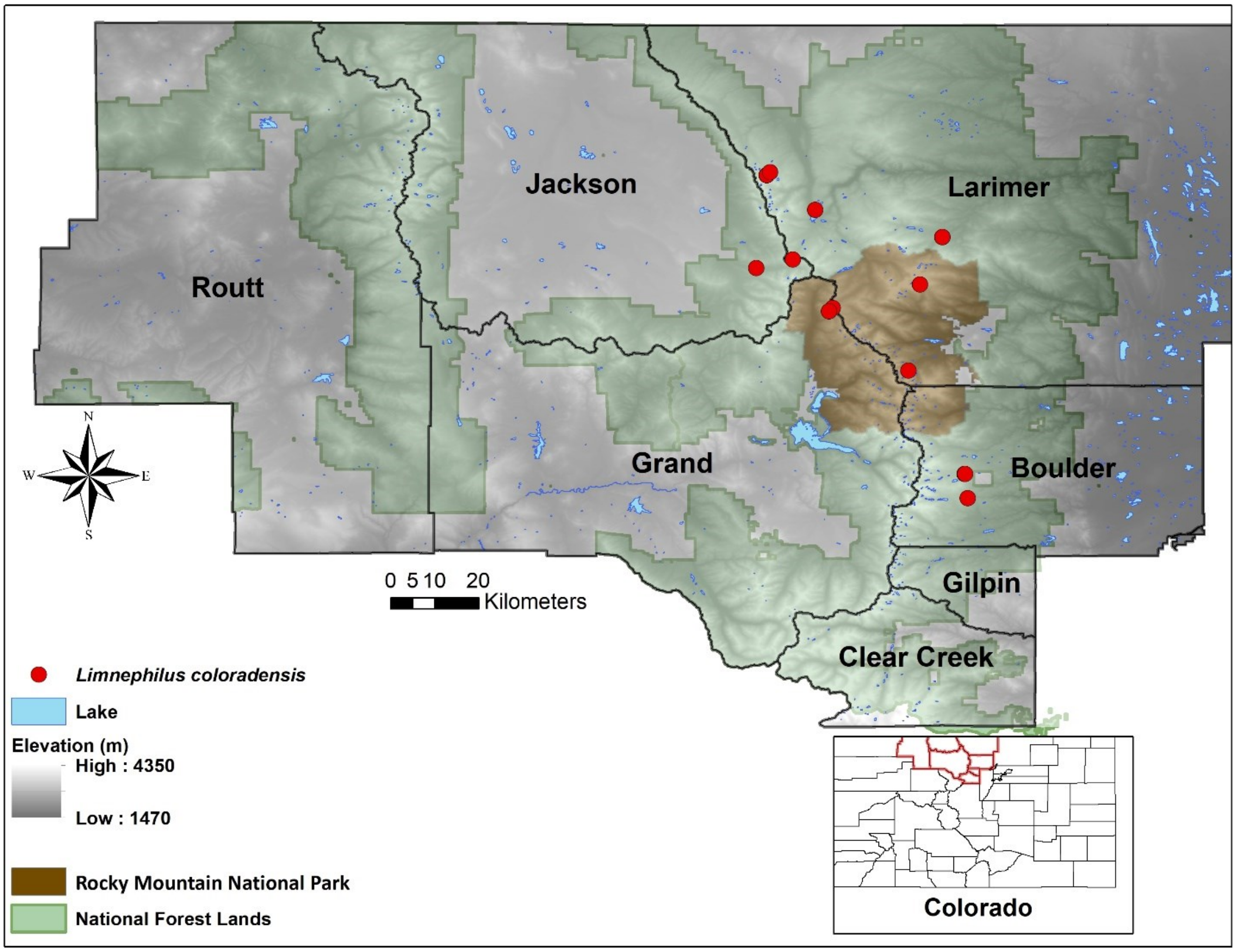

Figure 3.10. Distribution records of *Limnephilus coloradensis* (Limnephilidae: Trichoptera) in montane and alpine lakes of Boulder, Clear Creek, Gilpin, Grand, Jackson, Larimer, and Routt Counties, northern Colorado, USA.

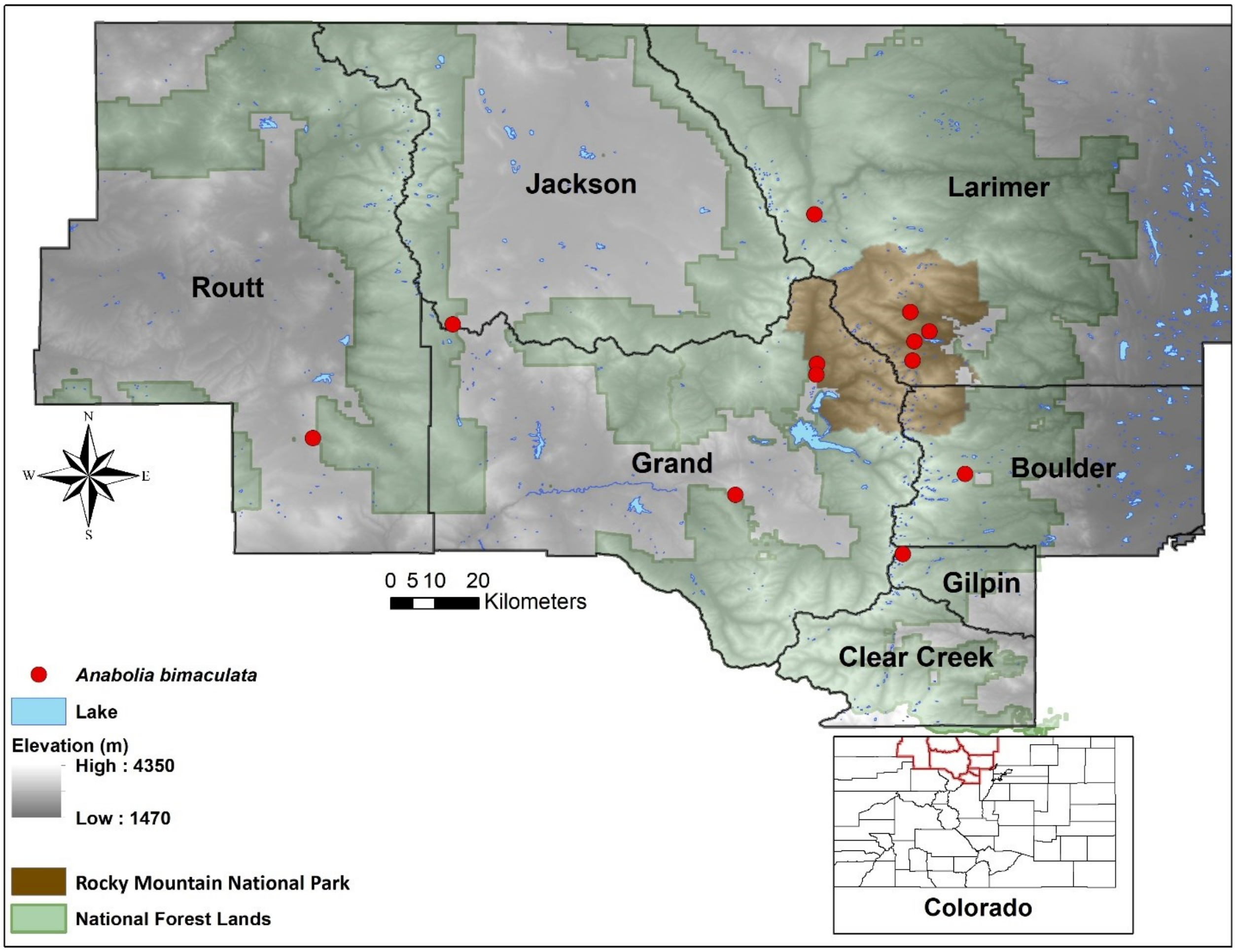

Figure 3.11. Distribution records of *Anabolia bimaculata* (Limnephilidae: Trichoptera) in montane and alpine lakes of Boulder, Clear Creek, Gilpin, Grand, Jackson, Larimer, and Routt Counties, northern Colorado, USA.

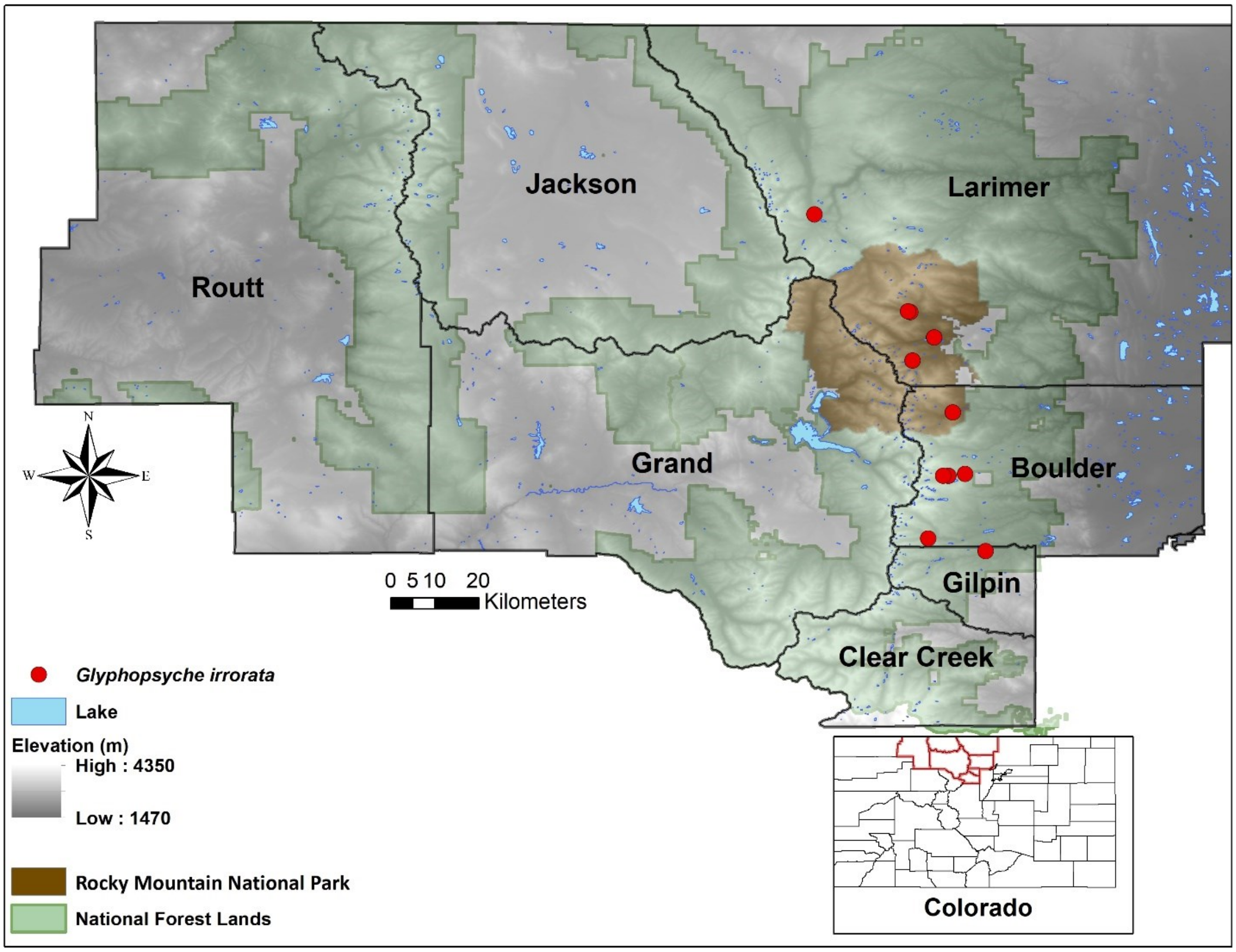

Figure 3.12. Distribution records of *Glyphopsyche irrorata* (Limnephilidae: Trichoptera) in montane and alpine lakes of Boulder, Clear Creek, Gilpin, Grand, Jackson, Larimer, and Routt Counties, northern Colorado, USA.

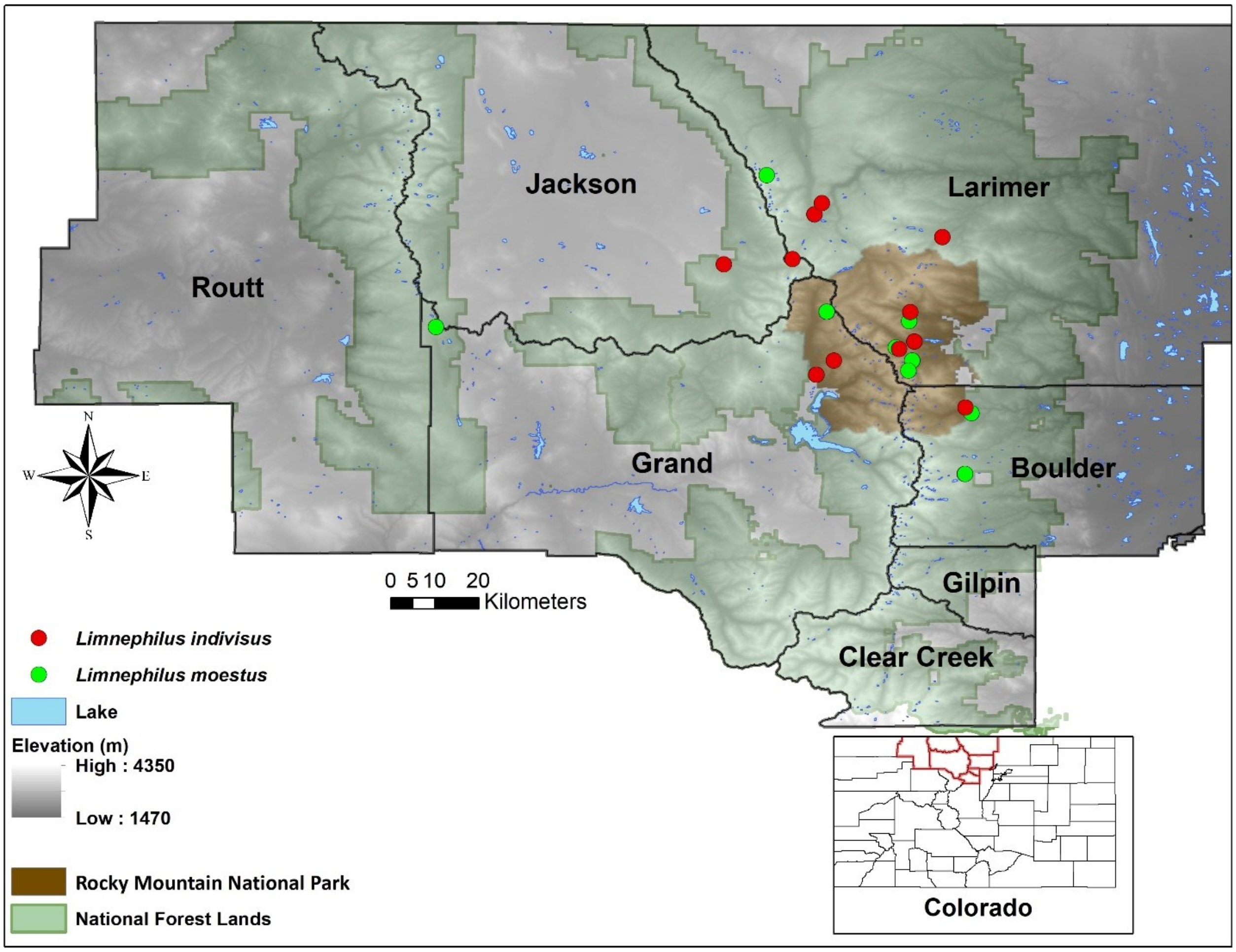

Figure 3.13. Distribution records of *Limnephilus indivisus* and *Limnephilus moestus* (Limnephilidae: Trichoptera) in montane and alpine lakes of Boulder, Clear Creek, Gilpin, Grand, Jackson, Larimer, and Routt Counties, northern Colorado, USA.

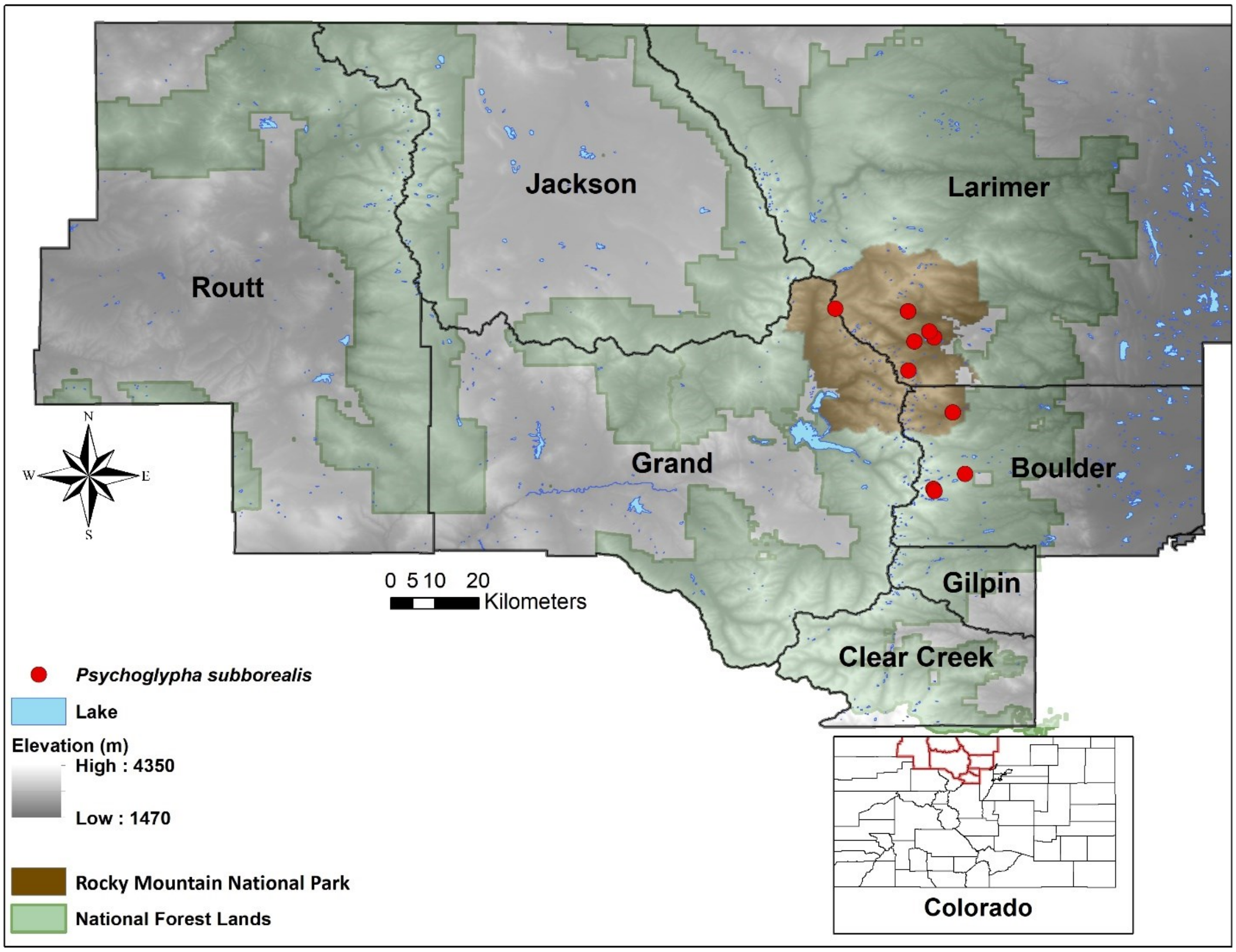

Figure 3.14. Distribution records of *Psychoglypha subborealis* (Limnephilidae: Trichoptera) in montane and alpine lakes of Boulder, Clear Creek, Gilpin, Grand, Jackson, Larimer, and Routt Counties, northern Colorado, USA.

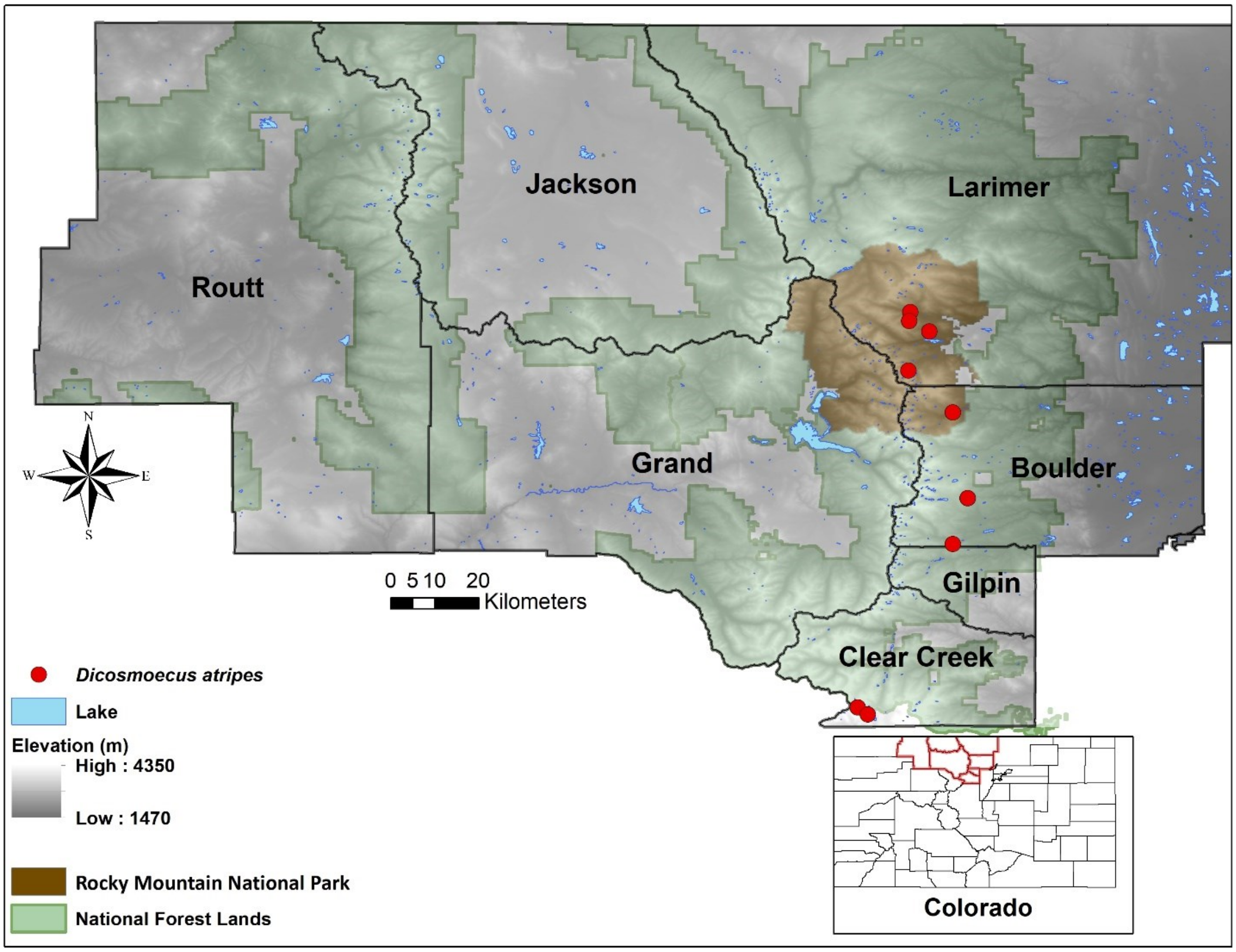

Figure 3.15. Distribution records of *Dicosmoecus atripes* (Limnephilidae: Trichoptera) in montane and alpine lakes of Boulder, Clear Creek, Gilpin, Grand, Jackson, Larimer, and Routt Counties, northern Colorado, USA.

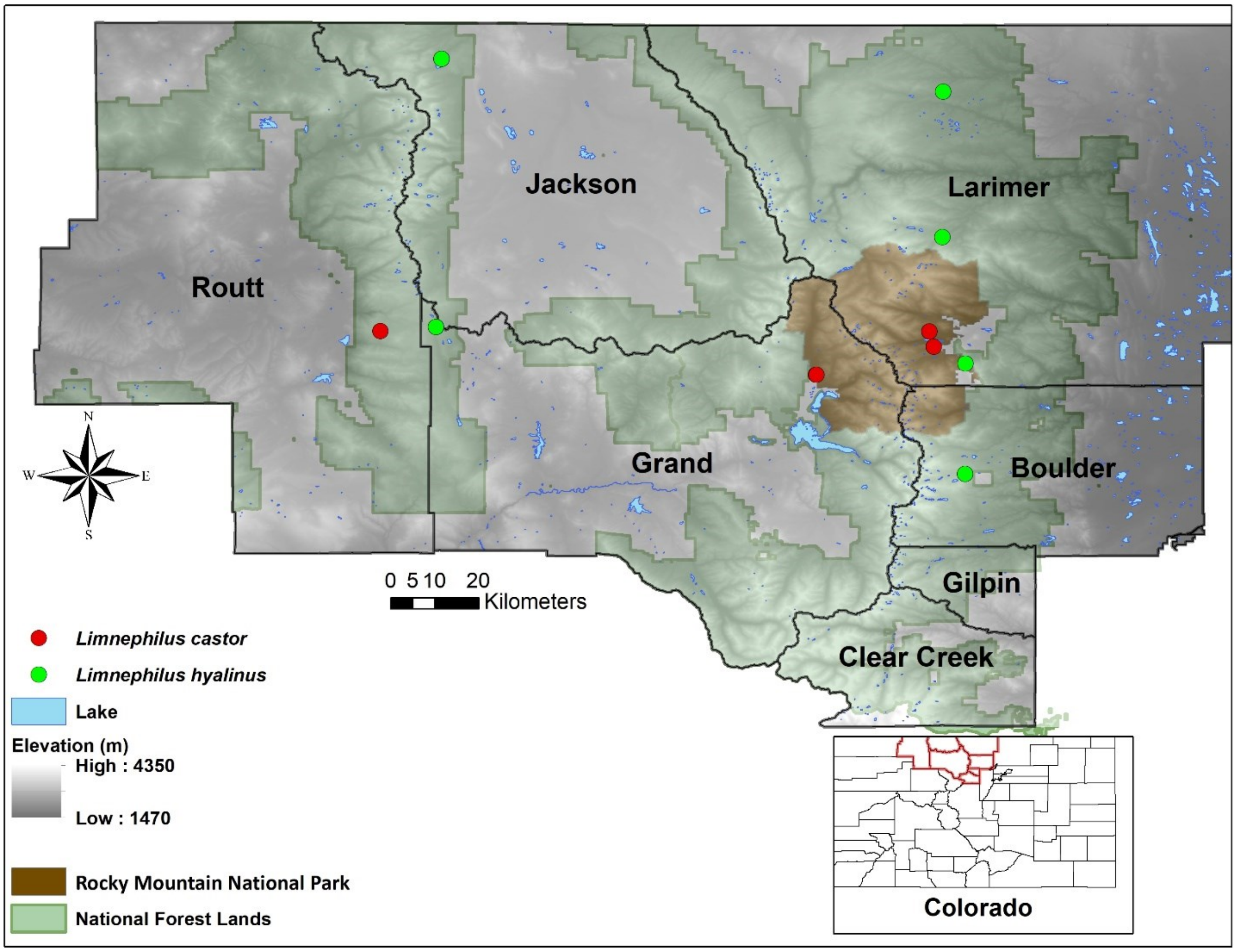

Figure 3.16. Distribution records of *Limnephilus castor* and *L*imnephilus *hyalinus* (Limnephilidae: Trichoptera) in montane and alpine lakes of Boulder, Clear Creek, Gilpin, Grand, Jackson, Larimer, and Routt Counties, northern Colorado, USA.

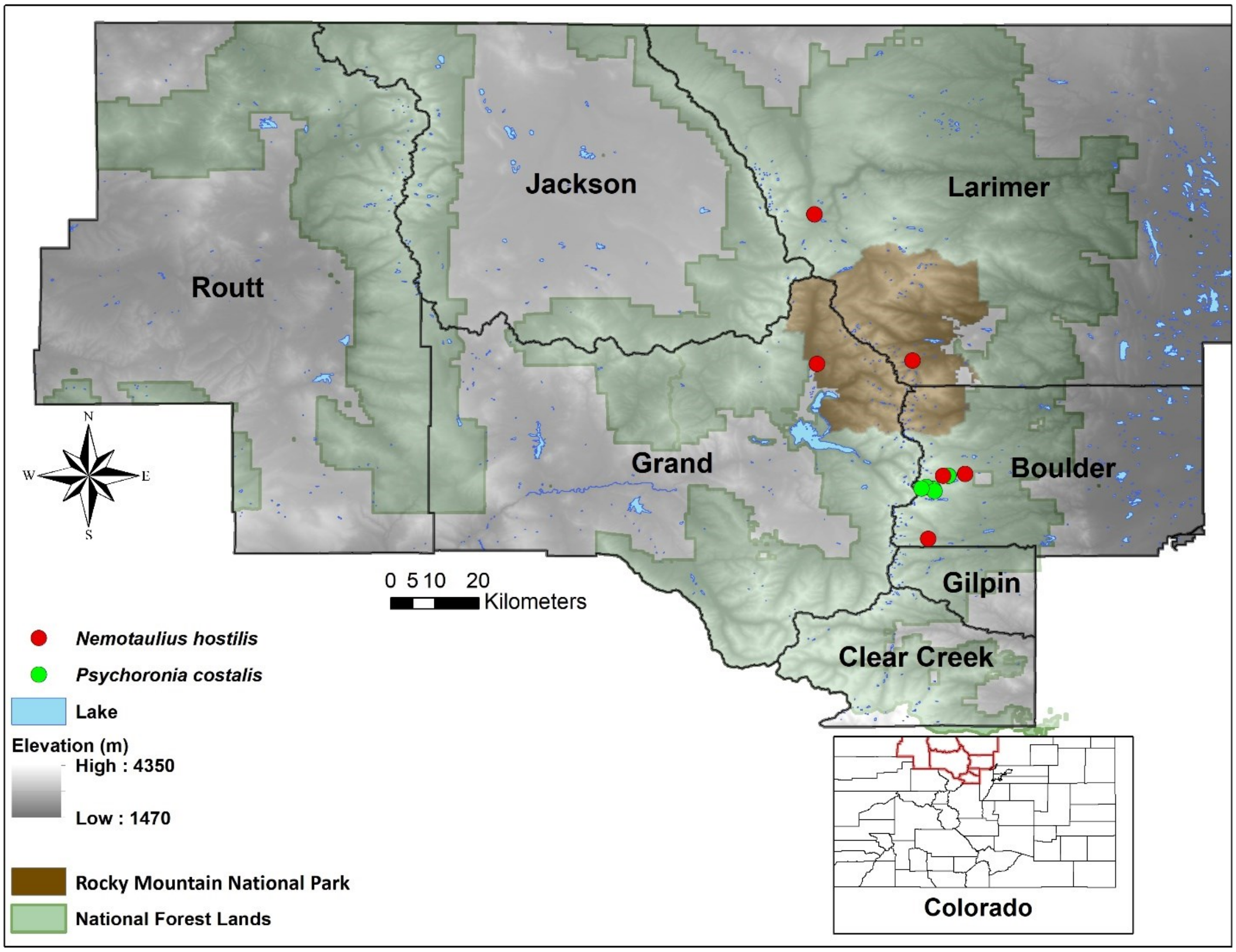

Figure 3.17. Distribution records of *Nemotaulius hostilis* and *Psychoronia costalis* (Limnephilidae: Trichoptera) in montane and alpine lakes of Boulder, Clear Creek, Gilpin, Grand, Jackson, Larimer, and Routt Counties, northern Colorado, USA.

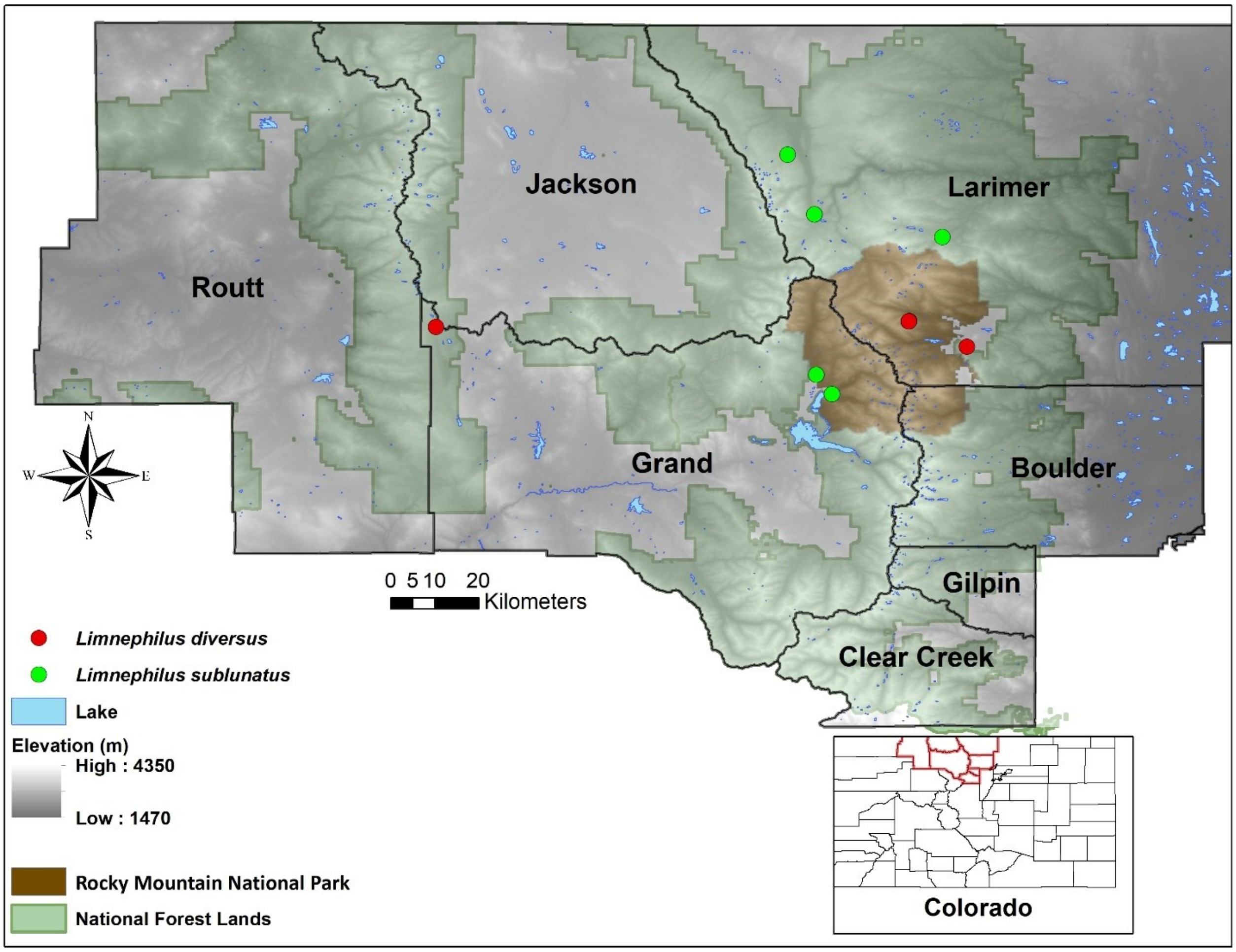

Figure 3.18. Distribution records of *Limnephilus diversus* and *Limnephilus sublunatus* (Limnephilidae: Trichoptera) in montane and alpine lakes of Boulder, Clear Creek, Gilpin, Grand, Jackson, Larimer, and Routt Counties, northern Colorado, USA.

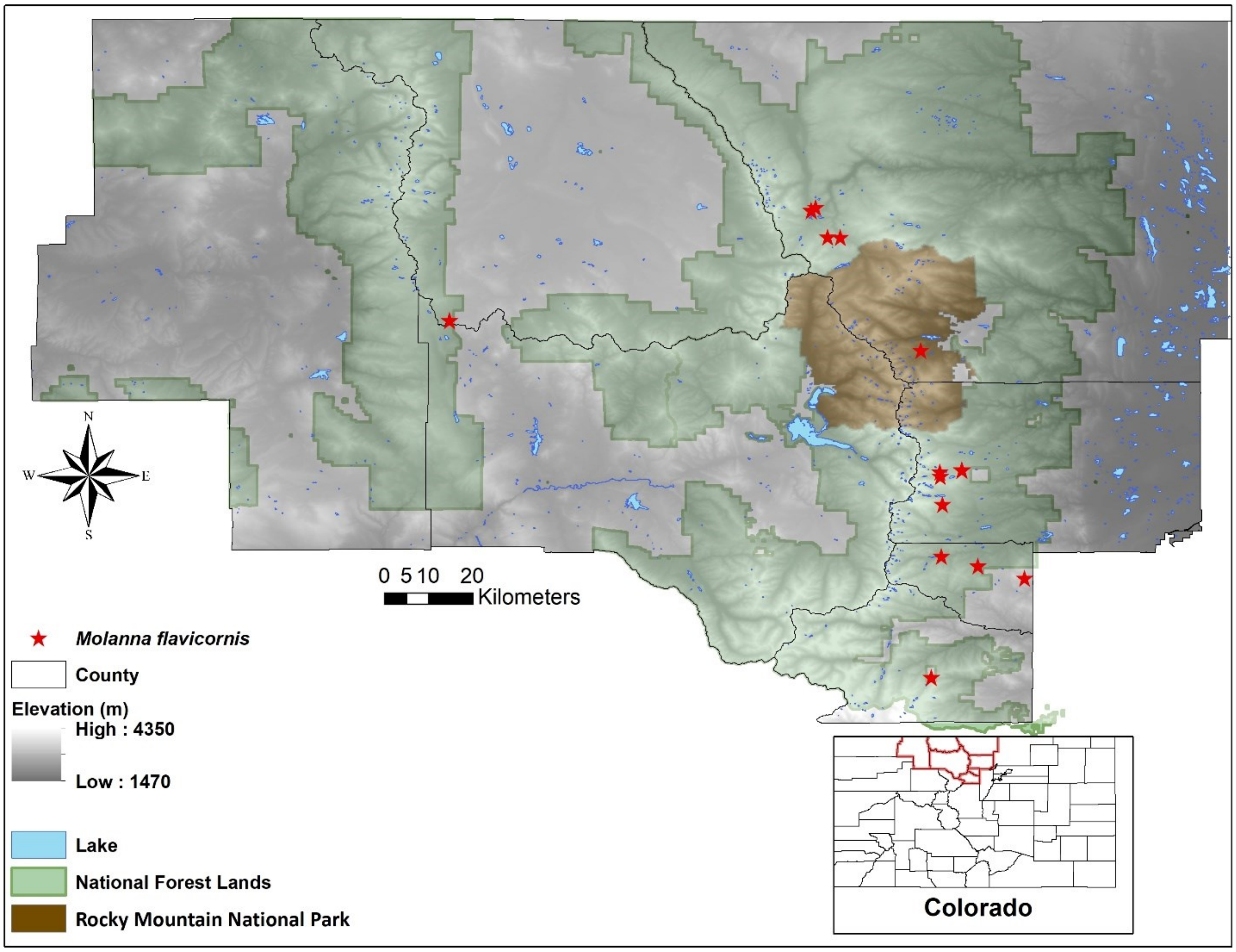

Figure 3.19. Distribution records of Molannidae (Trichoptera) in montane and alpine lakes of Boulder, Clear Creek, Gilpin, Grand, Jackson, Larimer, and Routt Counties, northern Colorado, USA.

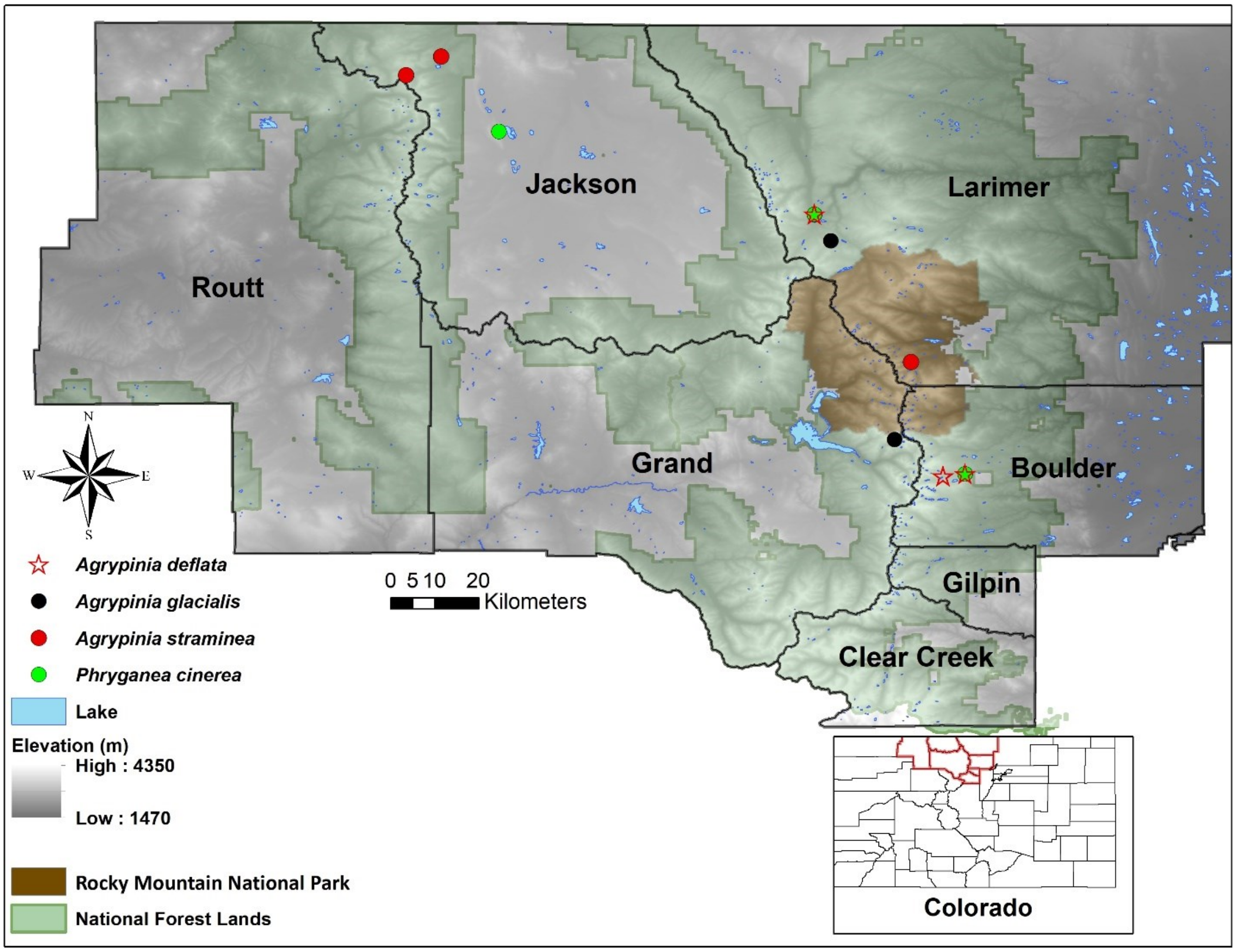

Figure 3.20. Distribution records of Phryganeidae (Trichoptera) in montane and alpine lakes of Boulder, Clear Creek, Gilpin, Grand, Jackson, Larimer, and Routt Counties, northern Colorado, USA.

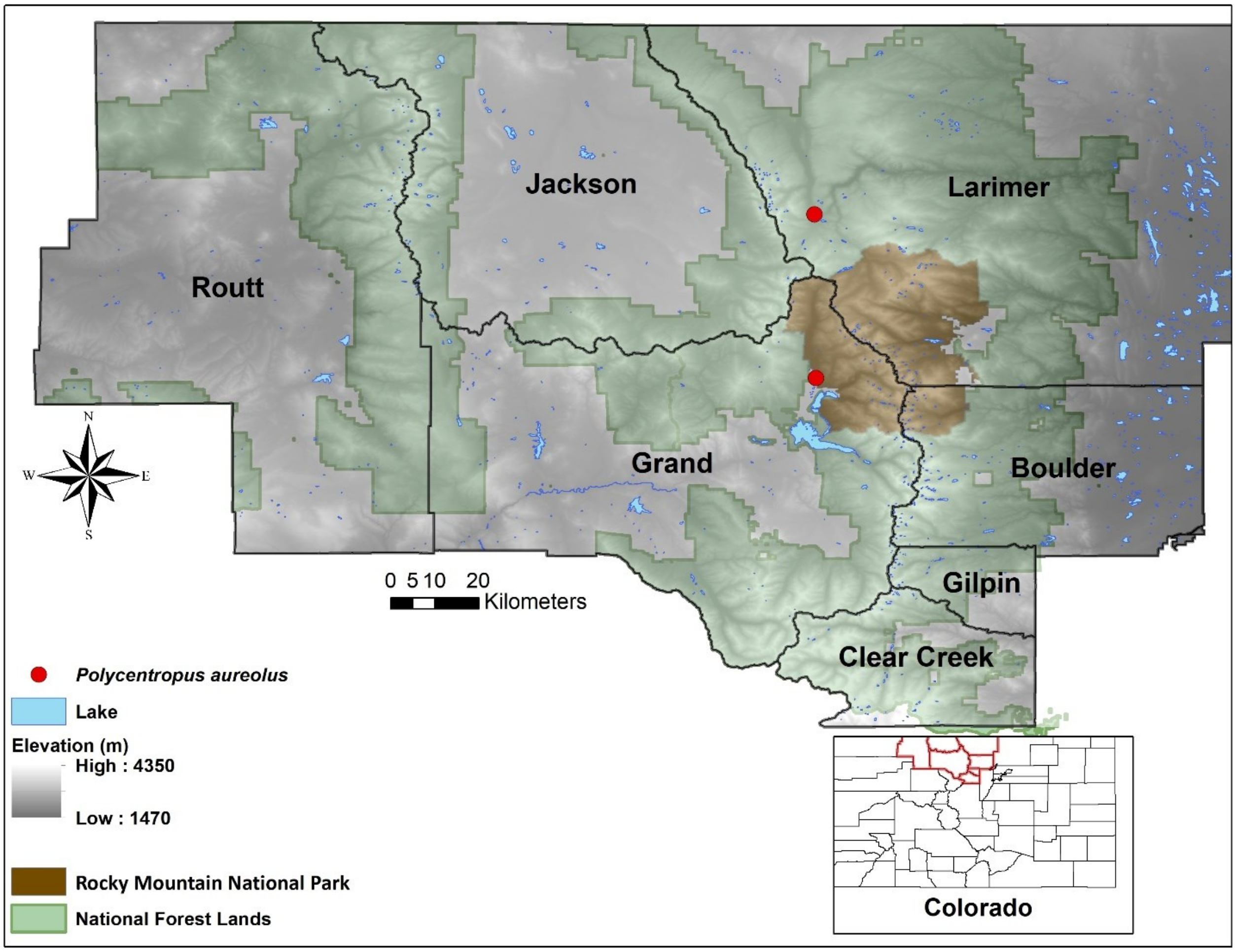

Figure 3.21. Distribution records of Polycentropodidae (Trichoptera) in montane and alpine lakes of Boulder, Clear Creek, Gilpin, Grand, Jackson, Larimer, and Routt Counties, northern Colorado, USA.

Table 3.1. Caddisfly (Trichoptera) records of the families Apataniidae, Hydroptilidae, Leptoceridae, Molannidae, Phryganeidae, and Polycentropodidae from montane and alpine lakes (following Pennak 1969) in Boulder, Clear Creek, Gilpin, Grand, Jackson, Larimer, and Routt Counties, northern Colorado, USA. Taxa are arranged alphabetically by family, genus, and species. Number of species for each family is listed after each respective family. Number of occurrence localities of each species is listed in parenthesis after county names.

Family	Genus	Species	Elevation m	Counties & locations
Apataniidae (1)	*Apatania* (1)	*Apatania zonella* (Zerrerstedt, 1840)	3,750-3,915	Boulder & Clear Creek (2)
Hydroptilidae (2)	*Agraylea* (1)	*Agraylea multipunctata* Curtis, 1834	2,510-3,100	Boulder, Gilpin, Larimer & Routt (6)
	Oxyethira (1)	*Oxyethira dualis* Morton, 1905	3,100	Boulder (1)
Leptoceridae (3)	*Mystacides* (2)	*Mystacides interjecta* (Banks, 1914)	2,550-3,200	Boulder, Gilpin, Grand, Jackson, & Larimer (12)
		Mystacides longicornis (Linnaeus, 1758	2,595	Larimer (1)
	Oecetis (1)	*Oecetis inconspicua* (Walker, 1852)	2,835-3,100	Boulder & Larimer (2)
Molannidae (1)	*Molanna* (1)	*Molanna flavicornis* Banks, 1914	2,675-3,240	Boulder, Clear Creek, Gilpin & Larimer (14)
Phryganeidae (4)	*Agrypnia* (3)	*Agrypnia deflata* (Milne, 1931)	2,835-3,200	Boulder & Larimer (3)
		Agrypnia glacialis Hagen,1873	3,030-3,240	Grand & Larimer (2)
		Agrypnia straminea Hagen, 1873	2,765-3,275	Jackson & Larimer (3)
	Phryganea (1)	*Phryganea cinerea* Walker, 1852	2,565-3,100	Boulder, Jackson & Larimer (3)
Polycentropodidae (1)	*Polycentropus (1)*	*Polycentropus aureolus* (Banks, 1930)	2,650-2,835	Grand & Larimer (2)

Table 3.2. Caddisfly (Trichoptera) records of the family Limnephilidae from montane and alpine lakes (following Pennak 1969) in Boulder, Clear Creek, Gilpin, Grand, Jackson, Larimer, and Routt Counties, northern Colorado, USA. Taxa are arranged alphabetically by genus and species. Number of species recorded in each genus and family is listed after each respective genus or family. Number of occurrence localities of each species is listed in parenthesis after counties.

Genus	Species	Elevation (m)	Counties & locations
Anabolia (1)	*Anabolia bimaculata* (Walker, 1852)	2,510-3,255	Boulder, Gilpin, Grand, Larimer & Routt (12)
Asynarchus (2)	*Asynarchus montanus* (Banks, 1907)	2,650-3,345	Boulder, Gilpin, Grand & Larimer (8)
	Asynarchus nigriculus (Banks, 1908)	2,545-3,695	Boulder, Clear Creek, Gilpin, Grand, Jackson & Larimer (28)
Dicosmoecus (1)	*Dicosmoecus atripes* (Hagen, 1875)	2,570-3,705	Boulder, Clear Creek & Larimer (9)
Glyphopsyche (1)	*Glyphopsyche irrorata* (Fabricius, 1781)	2,500-2,900	Boulder, Gilpin & Larimer (11)
Grammotaulius (1)	*Grammotaulius loretta* Denning, 1941	2,835	Larimer (1)
Hesperophylax (4)	*Hesperophylax consimilis* (Banks, 1900)	2,900-3,250	Grand, Larimer & Routt (3)
	Hesperophylax designatus (Walker, 1852)	2,550-3,635	Clear Creek, Gilpin, Grand & Larimer (8)
	Hesperophylax magnus Banks, 1918	2,500-3,155	Larimer (3)
	Hesperophylax occidentalis (Banks, 1908)	2,545-3,565	Boulder, Clear Creek, Grand, Jackson & Larimer (21)
Homophylax (1)	*Homophylax flavipennis* Banks, 1900	2,895-3,250	Boulder & Grand (3)
Lenarchus (2)	*Lenarchus brevipennis* (Banks, 1899)	2,860	Larimer (1)
	Lenarchus fautini (Denning, 1949)	2,850-3,210	Boulder & Larimer (2)
Limnephilus (20)	*Limnephilus abbreviatus* Banks, 1908	2,550-3,550	Boulder, Clear Creek, Gilpin, Grand, Jackson, Larimer & Routt (33)
	Limnephilus castor Ross & Merkley, 1952	2,550-2,830	Grand, Larimer & Routt (4)
	Limnephilus coloradensis (Banks, 1899)	2,795-3,345	Boulder, Grand, Jackson & Larimer (13)
	Limnephilus dispar McLachlan, 1875	3,100	Boulder (1)
	Limnephilus diversus (Banks, 1903)	2,625-3,360	Boulder, Grand & Larimer (4)
	Limnephilus externus Hagen, 1861	2,510-3,155	Boulder, Grand, Jackson, Larimer & Routt (19)
	Limnephilus hyalinus Hagen, 1861	2,540-3,100	Boulder, Grand, Jackson & Larimer (8)
	Limnephilus indivisus Walker, 1852	2,580-3,155	Boulder, Grand, Jackson & Larimer (11)

	Limnephilus janus Ross, 1938	2,510-3,210	Boulder, Gilpin, Grand, Jackson, Larimer & Routt (14)
	Limnephilus labus Ross, 1941	2,705-3,345	Boulder & Grand (2)
	Limnephilus moestus Banks, 1908	2,580-3,262	Boulder, Grand & Larimer (11)
	Limnephilus perpusillus Walker, 1852	3,100	Boulder (1)
	Limnephilus picturatus McLachlan, 1875	2,740-3,360	Boulder, Clear Creek, Grand, Jackson & Larimer (29)
	Limnephilus productus Banks, 1914	2,545	Grand (1)
	Limnephilus rhombicus (Linnaeus, 1758)	2,860	Grand (1)
	Limnephilus sansoni Banks, 1918	2,670-3,210	Boulder & Grand (2)
	Limnephilus secludens Banks, 1914	2,8353,140	Larimer (2)
	Limnephilus spinatus Banks, 1914	2,510-2,740	Jackson & Routt (2)
	Limnephilus sublunatus Provancher, 1877	2,550-2,918	Grand & Larimer (5)
	Limnephilus tarsalis (Banks, 1920)	3,100	Boulder (1)
	Limnephilus thorus Ross, 1938		Larimer (1)
Nemotaulius (1)	*Nemotaulius hostilis* (Hagen, 1873)	2,670-3,210	Boulder, Grand & Larimer (6)
Psychoglypha (1)	*Psychoglypha subborealis* (Banks,1924)	2,500-3,430	Boulder & Larimer (10)
Psychoronia (1)	*Psychoronia costalis* Banks, 1901	3,355-3,565	Boulder (5)

Table 3.3. Caddisfly (Trichoptera) records of species with fewer than four occurrence records from montane and alpine lakes (following Pennak 1969) in Boulder, Clear Creek, Gilpin, Grand, Jackson, Larimer, and Routt Counties, northern Colorado, USA. Taxa are arranged alphabetically by genus and species.

Species	Lake	County	Latitude N	Longitude W	Elevation (m)
Apataniidae					
Apatania zonella (Zerrerstedt, 1840)	Chasm Lake	Boulder	40.25972	-105.60281	3,750
	Summit Lake	Clear Creek	39.59861	-105.64172	3,915
Hydroptilidae					
Oxyethira dualis Morton, 1905	Wetland, Red Rock Lake	Boulder	40.08191	-105.54202	3,100
Leptoceridae					
Mystacides longicornis (Linnaeus, 1758)	Sheep Lake	Larimer	40.40511	-105.62167	2,595
Oecetis inconspicua (Walker, 1852)	Red Rock Lake	Boulder	40.081877	-105.54148	3,100
	Lost Lake, Co Rd103	Larimer	40.611854	-105.84870	2,835
Limnephilidae					
Grammotaulius loretta Denning, 1941	Lost Lake, Co Rd103	Larimer	40.611854	-105.84870	2,835
Hesperophylax consimilis (Banks, 1900)	Lake Irene Picnic Area	Grand	40.41401	-105.81939	3,250
	Upper Beaver Meadows Trailhead, RMNP	Larimer	40.37287	-105.61421	2,750
	Dumont Lake	Routt	40.40419	-106.63005	2,900
Hesperophylax magnus Banks, 1918	0.5 M E of Fern Lake Trail, RMNP	Larimer	40.33176	-105.67045	3,155
	Fern Lake	Larimer	40.33678	-105.67631	2,990
	Moraine Park, .8 M E Fern Lake	Larimer	40.360365	-105.60451	2,500
Homophylax flavipennis Banks, 1900	Science Lodge	Boulder	40.03210	-105.53591	2,895
	Wild Basin Trailhead, RMNP	Boulder	40.20779	-105.56654	2,739
	Lake Irene Picnic Area	Grand	40.41401	-105.81939	3,231
Lenarchus brevipennis (Banks, 1899)	Drainage along Twin Lake Trail	Larimer	40.626098	-105.83601	2,860
Lenarchus fautini (Denning, 1949)	Long Lake	Boulder	40.072535	-105.59194	3,210
	Wetland, NE Lost Lake	Larimer	40.61322	-105.84493	2,850
Limnephilus dispar McLachlan, 1875	Wetland, W of Red Rock Lake	Boulder	40.08191	-105.54202	3,100

Limnephilus labus Ross, 1941	Woodland Lake	Boulder	39.954369	-105.66508	3,345
	Tolland	Gilpin	39.907704	-105.58749	2,705
Limnephilus perpusillus Walker, 1852	Wetland, W of Red Rock L.	Boulder	40.08191	-105.54202	3,100
Limnephilus productus Banks, 1914	Shadow Mountain Dam, RMNP	Grand	40.20889	-105.83504	2,545
Limnephilus rhombicus (Linnaeus, 1758)	Pond, off FS 100, off Hwy 40	Grand	40.38205	-106.62177	2,860
Limnephilus sansoni Banks, 1918	west of Long Lake Trailhead	Boulder	40.07770	-105.58647	3,210
	Green Mountain Employee Area	Grand	40.30656	-105.84317	2,670
Limnephilus secludens Banks, 1914	Forest Lake	Larimer	40.38963	-105.73494	3,140
	Lost Lake	Larimer	40.611854	-105.84870	2,835
Limnephilus spinatus Banks, 1914	Gould	Jackson	40.50941	-106.03418	2,740
	Eagle Rock Lake	Routt	40.15483	-106.87337	2,510
Limnephilus tarsalis (Banks, 1920)	Near Ward	Boulder	40.083518	-105.51311	2,870
Limnephilus thorus Ross, 1938	Rocky Mountain National Park	Larimer			
Phryganeidae					
Agrypnia deflata (Milne, 1931)	Pond, W of Long Lake	Boulder	40.07750	-105.58610	3,200
	Red Rock Lake	Boulder	40.081877	-105.54148	3,100
	Lost Lake, CoRd103	Larimer	40.611854	-105.84870	2,835
Agrypnia glacialis Hagen, 1873	Stone Lake	Grand	40.557519	-105.81536	3,240
	Trap Lake	Larimer	40.151977	-105.68485	3,030
Agrypnia straminea Hagen, 1873	Big Creek Lakes	Jackson	40.93360	-106.61140	2,765
	Seven Lakes	Jackson	40.89580	-106.68250	3,275
	Nymph Lake	Larimer	40.310189	-105.65165	2,906
Phryganea cinerea Walker, 1852	Red Rock Lake	Boulder	40.081877	-105.54148	3,100
	Lake John	Jackson	40.78081	-106.49310	2,565
	Lost Lake	Larimer	40.611854	-105.84871	2,835
Polycentropodidae					
Polycentropus aureolus (Banks, 1930)	Harbison Picnic Area, RMNP	Grand	40.27751	-105.84562	2,650
	Lost Lake	Larimer	40.611854	-105.84871	2,835

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APPENDICES

Appendix 1. Presence records of the Hudsonian Emerald, *Somatochlora hudsonica* of montane and alpine lakes (following Pennak 1969) Colorado Wyoming, USA, 2021.

Species	Longitude	Latitude	Sex	Collectors	State	County	Location	Date	Elevation (m)
S. hudsonica	-105.541489	40.081877	1m	O. & C. Flint	Colorado	Boulder	Red Rock Lake	31-VII-1998	3,100
S. hudsonica	-105.541489	40.081877	1m	O. & C. Flint	Colorado	Boulder	Red Rock Lake	31-VII-1998	3,100
S. hudsonica	-105.541489	40.081877	1m	O. & C. Flint	Colorado	Boulder	Red Rock Lake	31-VII-1998	3,100
S. hudsonica	-105.541489	40.081877	1m	O. & C. Flint	Colorado	Boulder	Red Rock Lake	31-VII-1998	3,100
S. hudsonica	-105.541489	40.081877	1m	O. & C. Flint	Colorado	Boulder	Red Rock Lake	31-VII-1998	3,100
S. hudsonica	-105.541489	40.081877	1m	O. & C. Flint	Colorado	Boulder	Red Rock Lake	31-VII-1998	3,100
S. hudsonica	-105.541489	40.081877	1m	O. & C. Flint	Colorado	Boulder	Red Rock Lake	31-VII-1998	3,100
S. hudsonica	-105.541489	40.081877	1m	O. & C. Flint	Colorado	Boulder	Red Rock Lake	31-VII-1998	3,100
S. hudsonica	-105.578139	40.011842		B. & I. Prather.	Colorado	Boulder	Rainbow Lakes, lower	06-VIII-2005	3,098
S. hudsonica	-105.581107	40.012185		B. & I. Prather	Colorado	Boulder	Rainbow Lakes, middle	10-VIII-2003	3,111
S. hudsonica	-105.578139	40.011842		B. & I. Prather	Colorado	Boulder	Rainbow Lakes, lower	06-VIII-2005	3,098
S. hudsonica	-105.578139	40.011842		Unknown	Colorado	Boulder	Rainbow Lakes	no date	3,098
S. hudsonica	-105.449624	40.084533		Cooper, A. & Cooper, J.	Colorado	Boulder	Gold Lake	26-VIII-2008	2,630
S. hudsonica	-105.578139	40.011842		D. Mouchene	Colorado	Boulder	Rainbow Lakes	10-VIII-2018	3,098
S. hudsonica	-105.578139	40.011842		D. Mouchene	Colorado	Boulder	Rainbow Lakes	07-VIII-2018	3,098
S. hudsonica	-105.578139	40.011842		D. Czaplak	Colorado	Larimer	Rainbow Lakes	04-VII-2013	3,098
S. hudsonica	-105.509781	39.9777604		Unknown	Colorado	Boulder	Mud Lake	no date	2,552
S. hudsonica	-105.541489	40.081877		H.G. Rodeck	Colorado	Boulder	Red Rock Lake	10-VII-1939	3,098
S. hudsonica	-105.578139	40.011842		Unknown	Colorado	Boulder	Rainbow Lakes, lower	10-VIII-2003	3,098
S. hudsonica	-105.578139	40.011842		D. Mouchene	Colorado	Boulder	Rainbow Lakes	no date	3,098
S. hudsonica	-105.54171	40.08161		A. Cooper & J. Cooper	Colorado	Boulder	Unknown	06-VIII-2008	
S. hudsonica	-105.514395	40.0975		Voss, K. & Loewy, K	Colorado	Boulder	Barron Pond NE	no date	2,837

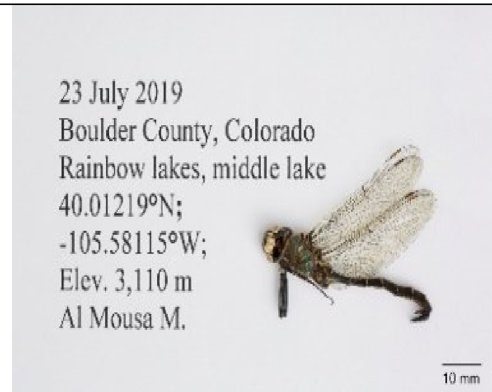
S. hudsonica	-105.52409	40.092649		Voss, K. & Loewy, K	Colorado	Boulder	Barron Pond SW	no date	2,940
S. hudsonica	-105.530809	39.989745		Voss, K. & Loewy, K	Colorado	Boulder	Delonde Ponds	no date	2,600
S. hudsonica	-105.519278	39.982477		Voss, K. & Loewy, K	Colorado	Boulder	Caribou Open Space, Caribou N	no date	2,613
S. hudsonica	-105.513372	40.083606		Voss, K. & Loewy, K	Colorado	Boulder	Duck Lake	no date	2,870
S. hudsonica	-105.463824	39.951841		Voss, K. & Loewy, K	Colorado	Boulder	Giggey West	no date	2,590
S. hudsonica	-105.5022	40.0008		Voss, K. & Loewy, K	Colorado	Boulder	Minnick-Thompson	no date	2,610
S. hudsonica	-105.509781	39.9777604		Voss, K. & Loewy, K	Colorado	Boulder	Mud Lake	no date	2,552
S. hudsonica	-105.541489	40.081877	4m 3f	M. Al Mousa	Colorado	Boulder	Red Rock Lake	17-VII-2019	3,100
S. hudsonica	-105.541489	40.081877	1m	M. Al Mousa	Colorado	Boulder	Red Rock Lake	06-VIII-2019	3,100
S. hudsonica	-105.541489	40.081877	1m	M. Al Mousa	Colorado	Boulder	Red Rock Lake	20-VIII-2019	3,100
S. hudsonica	-105.541489	40.081877	1 m	M. Al Mousa	Colorado	Boulder	Red Rock Lake	04-VIII-2020	3,100
S. hudsonica	-105.541489	40.081877		M. Al Mousa	Colorado	Boulder	Red Rock Lake	04-VIII-2020	3,100
S. hudsonica	-105.578139	40.011842	7 m	M. Al Mousa	Colorado	Boulder	Rainbow Lakes, lower	23-VII-2019	3,098
S. hudsonica	-105.581107	40.012185	6m 3f	M. Al Mousa	Colorado	Boulder	Rainbow Lakes, middle	23-VII-2019	3,110
S. hudsonica	-105.530846	39.989733		Voss, K. & Loewy, K	Colorado	Boulder	Delonde Creek	no date	2,560
S. hudsonica	-105.566623	39.938927		Unknown	Colorado	Boulder	Eldora Lakes	01-VII-1914	2,830
S. hudsonica	-105.53344	40.030731		Lanham	Colorado	Boulder	Gentian Lake	13-VII-1939	2,900
S. hudsonica	-105.541489	40.081877	7m 1f	M. Al Mousa	Colorado	Boulder	Red Rock Lake	25-VII-2021	3,100
S. hudsonica	-105.578139	40.011842	4m	M. Al Mousa	Colorado	Boulder	Rainbow Lakes, lower	30-VII-2021	3,098
S. hudsonica	-105.581107	40.012185	6 m	M. Al Mousa	Colorado	Boulder	Rainbow Lakes, middle	30-VII-2021	3,110
S. hudsonica	-105.58356	40.012204	4m	M. Al Mousa	Colorado	Boulder	Rainbow Lakes, upper	30-VII-2021	3,127

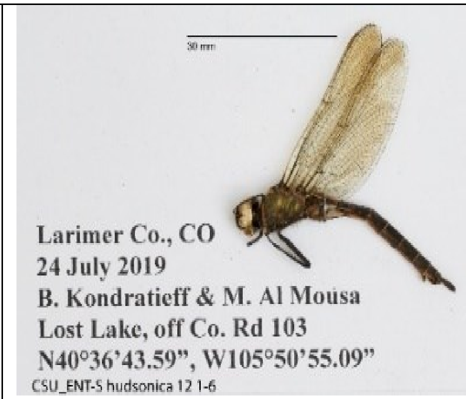
S. hudsonica	-105.586393	40.077635	1 m	M. Al Mousa	Colorado	Boulder	small lake, W. of Long Lake	17-VIII-2021	3,100
S. hudsonica	-105.59472	39.907222		Unknown	Colorado	Gilpin	South Boulder Park	23-VI-1914	2,864
S. hudsonica	-105.615039	39.888955		Unknown	Colorado	Gilpin	Teller Lakes	01-VII-1914	2,935
S. hudsonica	-105.615039	39.888955		Unknown	Colorado	Gilpin	Teller Lakes	06-VII-1915	2,935
S. hudsonica	-105.662074	39.916176	1m	M. Al Mousa	Colorado	Gilpin	Forest Lakes, lower lake	15-VIII-2019	3,245
S. hudsonica	-105.667529	39.917673	1m	M. Al Mousa	Colorado	Gilpin	forest lakes, middle	15-VIII-2019	3,257
S. hudsonica	-105.662074	39.916176	1m	M. Al Mousa	Colorado	Gilpin	Forest Lakes, lower lake	28-VII-2021	3,245
S. hudsonica	-105.667529	39.917673	2m	M. Al Mousa	Colorado	Gilpin	Forest lakes, middle	28-VII-2021	3,257
S. hudsonica	-105.673667	39.921143	2m	M. Al Mousa	Colorado	Gilpin	Forest lakes, upper	28-VII-2021	3,307
S. hudsonica	-105.848769	40.611442	1m	O. & C. Flint	Colorado	Larimer	Lost Lake, off Rd. 103	13-VII-2011	2,835
S. hudsonica	-105.848769	40.611442	1m	O. & C. Flint	Colorado	Larimer	Lost Lake, off Rd. 103	13-VII-2011	2,835
S. hudsonica	-105.848769	40.611442		B. Kondratieff	Colorado	Larimer	Lost Lake, off Co. Rd 103	08-VIII-2011	2,835
S. hudsonica	-105.848769	40.611442		D. Letnerman	Colorado	Larimer	Lost Lake, off Rd. 103	21-VII-2009	2,835
S. hudsonica	-105.848769	40.611442		B. & I. Prather	Colorado	Larimer	Lost Lake, near Chambers	16-VII-2010	2,835
S. hudsonica	-105.848769	40.611442		B. Kondratieff	Colorado	Larimer	Lost Lake, off Rd.103	08-VIII-2011	2,835
S. hudsonica	-105.848769	40.611442		B. Kondratieff	Colorado	Larimer	Lost Lake, off Rd. 103	08-VIII-2011	2,835
S. hudsonica	-105.848769	40.611442		B. & I. Prather	Colorado	Larimer	Lost Lake, near Chambers	16-VII-0000	2,835
S. hudsonica	-105.848769	40.611442		B. Kondratieff	Colorado	Larimer	Lost Lake, off Rd.103	08-VIII-2011	2,835
S. hudsonica	-105.848769	40.611442		B. Kondratieff	Colorado	Larimer	Lost Lake, off Rd. 103	08-VIII-2011	2,835

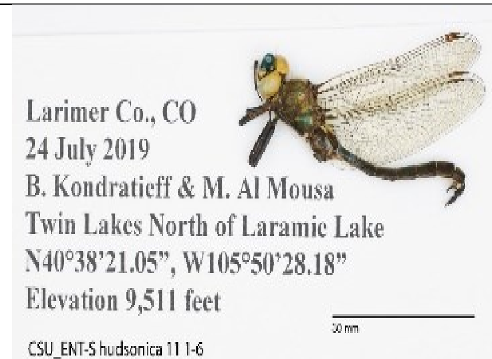
S. hudsonica	-105.848769	40.611442		B. Kondratieff	Colorado	Larimer	Lost Lake, off Rd.103	08-VIII-2011	2,835
S. hudsonica	-105.848769	40.611442		B. Kondratieff	Colorado	Larimer	Lost Lake, off Rd. 103	08-VIII-2011	2,835
S. hudsonica	-105.848769	40.611442		Unknown	Colorado	Larimer	Lost Lake	no date	2,835
S. hudsonica	-105.848769	40.611442	1m	O. & C. Flint	Colorado	Larimer	Lost Lake, off Rd. 103	13-VII-2011	2,835
S. hudsonica	-105.841261	40.639285		B. & I. Prather	Colorado	Larimer	Twin Lakes Area	10-VII-2009	2,895
S. hudsonica	-105.841261	40.639285		B. & I. Prather	Colorado	Larimer	Twin Lakes Area	10-VII-2009	2,895
S. hudsonica	-105.841261	40.639285		Unknown	Colorado	Larimer	Twin Lakes Area	no date	2,895
S. hudsonica	-105.841261	40.639285		Cooper, A. & Cooper, J.	Colorado	Larimer	Twin Lakes	17-VII-2017	2,895
S. hudsonica	-105.639988	40.346363		D.Czaplak	Colorado	Larimer	Cub Lake Trail, RMNP	04-VII-2013	2,635
S. hudsonica	-105.624776	40.326629		Caswell	Colorado	Larimer	Bierstadt Lake	28-VII-1954	2,873
S. hudsonica	-105.848707	40.611854		R. Hopper	Colorado	Larimer	Lost Lake	30-VI-2020	2,835
S. hudsonica	-105.848707	40.611854		R. Hopper	Colorado	Larimer	Lost Lake	03-VIII-2019	2,835
S. hudsonica	-105.834156	40.634893	2m	B. Kondratieff & M. Al Mousa	Colorado	Larimer	Lost Lake, off Rd. 103	22-VII-2019	2,886
S. hudsonica	-105.848707	40.611854	3m 1f	B. Kondratieff & M. Al Mousa	Colorado	Larimer	Lost Lake, Co.Rd 103	22-VII-2019	2,835
S. hudsonica	-105.839773	40.617788	3 m	B. Kondratieff & M. Al Mousa	Colorado	Larimer	Laramie Lake	22-VII-2019	2,845
S. hudsonica	-105.815366	40.557519	12m2f	M. Al Mousa	Colorado	Larimer	Trap Lake,	30-VII-2019	3,030
S. hudsonica	-105.937108	40.719377	m	M. Al Mousa	Colorado	Larimer	Lost Lake, Rawah	31-VII-2019	3,100
S. hudsonica	-105.848707	40.611854	2m	M. Al Mousa	Colorado	Larimer	Lost Lake, Co Rd 103	07-VII-2020	2,835
S. hudsonica	-105.86904	40.541234	1m	M. Al Mousa	Colorado	Larimer	Zimmerman Lake	17-VII-2021	3,196
S. hudsonica	-105.498918	39.553555		C. Praque, et al.	Colorado	Park	Mud Lakes	31-VII-1994	3,255

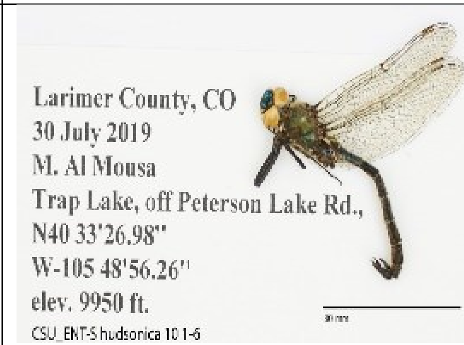
S. hudsonica	-106.146	41.0583	1m	O. & C. Flint	Wyoming	Albany	Bear Gluch Way Station, off Rd. 230	15-VII-2011	2,835
S. hudsonica	-106.0777	40.827		Molnar & Laving	Wyoming	Albany	Medicine Bow Mountains	19-VII-1937	3,261
S. hudsonica	-106.101388	41.259444		R. Lavigne	Wyoming	Albany	Little Laramie River, North Fork	04-IX-1978	
S. hudsonica	-106.146	41.0583	Male	O. & C. Flint	Wyoming	Albany	Bear Gluch Way Station, off Rd. 230	15-VII-2011	2,835
S. hudsonica	-106.146	41.0583	Male	O. & C. Flint	Wyoming	Albany	Bear Gluch Way Station, off Rd. 230	15-VII-2011	2,835
S. hudsonica	-106.178503	41.345436	1m	M. Al Mousa	Wyoming	Albany	Hanging Lake, Hwy 130	18-VII-2021	2,770
S. hudsonica	-106.178503	41.345436	1m	M. Al Mousa & B. Kondratieff	Wyoming	Albany	Hanging Lake, Hwy 130	21-VII-2020	2,770
S. hudsonica	-106.385397	41.436623	Male	O. & C. Flint	Wyoming	Carbon	Turpin Reservoir	28-VII-1998	2,867
S. hudsonica	-106.368984	41.502252		Rader & Belish	Wyoming	Carbon	Long Lake,	17-VII-1996	2,726
S. hudsonica	-106.949197	44.301753		A. Thompson	Wyoming	Johnson	Middle Fork Cambground, Bighorn NF	14-VIII-2014	2,270
S. hudsonica	-109.779198	43.082603		Mower R.C.	Wyoming	Sublette	Trapper Lake	27-VII-2004	2,956
S. hudsonica	-110.512222	43.838055		Bick & Hornuff	Wyoming	Teton	Moran Junction	25-VII-1971	2,082

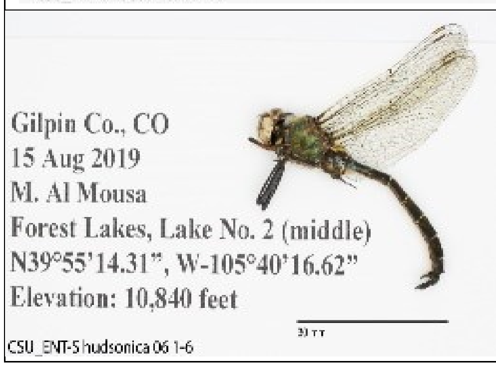
Appendix 2. Records of the Hudsonian Emerald, *Somatochlora hudsonica* in the Arapaho & Roosevelt National Forest and Medicine Bow & Routt National Forest, Northcentral Colorado, and southern Wyoming, summer 2019-2021.

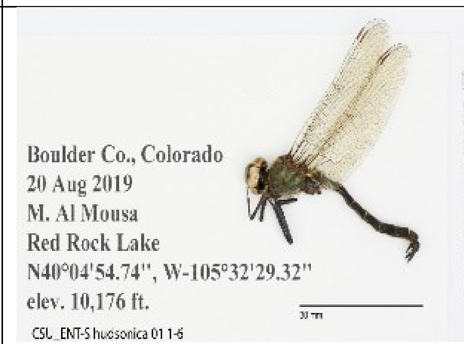




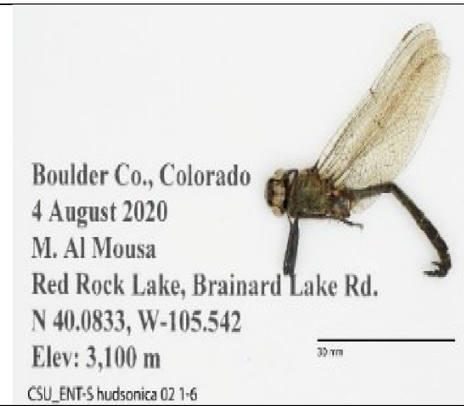


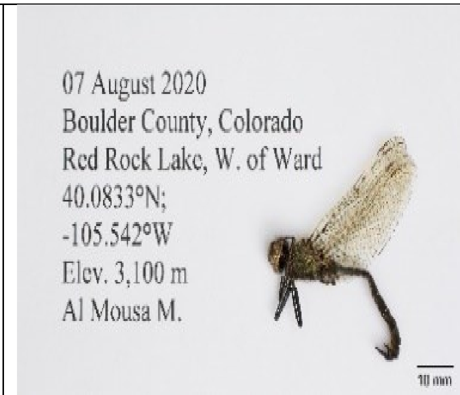




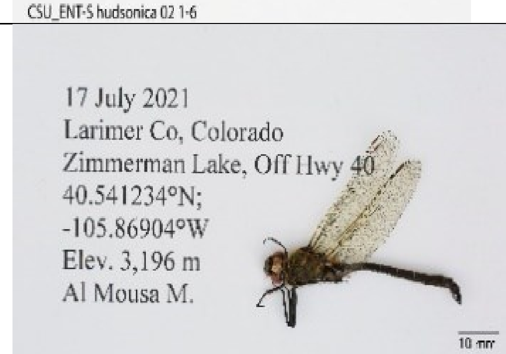


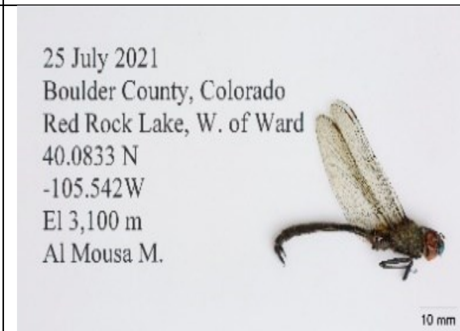

Larimer Co., CO
7 July 2020
M. Al Mousa
Lost Lake
Off Co Rd 103
N40.61201, W-105.8488
Elevation 2,835 meters
CSU_ENT S hudsonica 04 1 6


Boulder Co., Colorado
4 August 2020
M. Al Mousa
Red Rock Lake, Brainard Lake Rd.
N 40.0833, W-105.542
Elev: 3,100 m
CSU_ENT-S hudsonica 02 1-6

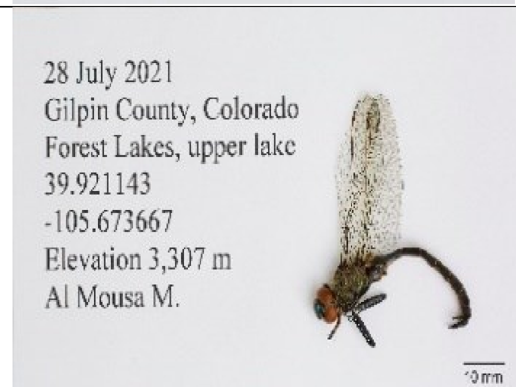

07 August 2020
Boulder County, Colorado
Red Rock Lake, W. of Ward
40.0833°N;
-105.542°W
Elev. 3,100 m
Al Mousa M.
10 mm


18 July 2021
Albany County, Wy
Hanging Lake Hanging Lake, off Hwy 130
El 2,770 m
41.43543 N
-106.1786 W
Al Mousa M.


17 July 2021
Larimer Co, Colorado
Zimmerman Lake, Off Hwy 40
40.541234°N;
-105.86904°W
Elev. 3,196 m
Al Mousa M.


25 July 2021
Boulder County, Colorado
Red Rock Lake, W. of Ward
40.0833 N
-105.542W
El 3,100 m
Al Mousa M.
10 mm

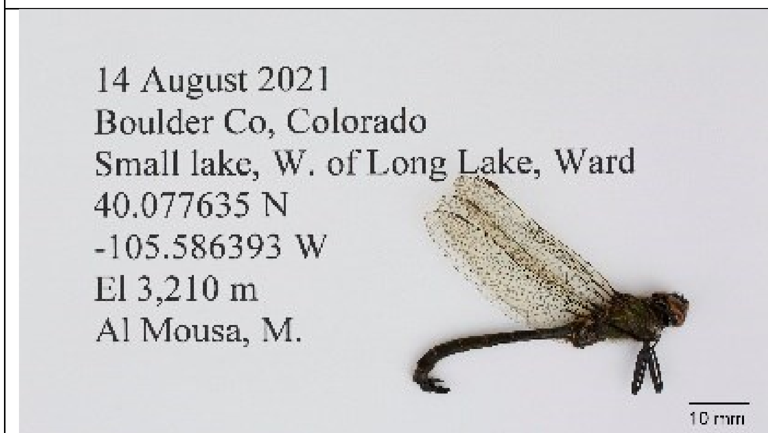

28 July 2021
Gilpin County, Colorado
Forest Lakes, middle lake
39.917596
-105.667582
Elevation 3,257 m
Al Mousa M.

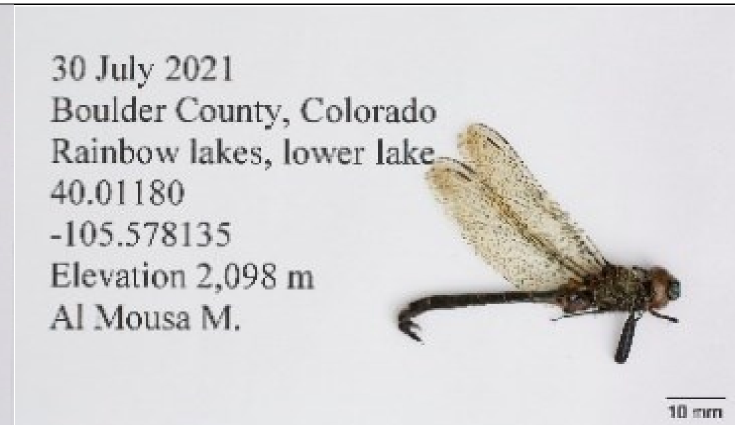

28 July 2021
Gilpin County, Colorado
Forest Lakes, upper lake
39.921143
-105.673667
Elevation 3,307 m
Al Mousa M.


28 July 2021
Gilpin County, Colorado
Forest Lakes, lower lake
39.916184
-105.662174
Elevation 3,245 m
Al Mousa M.
10 mm


30 July 2021
Boulder County, Colorado
Rainbow lakes, middle lake
40.01219
-105.58115
Elevation 3,110 m
Al Mousa M.
10 mm


30 July 2021
Boulder County, Colorado
Rainbow lakes, upper lake
40.012183
-105.585455
Elevation 3,127 m
Al Mousa M.
10 mm


14 August 2021
Boulder Co, Colorado
Small lake, W. of Long Lake, Ward
40.077635 N
-105.586393 W
El 3,210 m
Al Mousa, M.
10 mm


30 July 2021
Boulder County, Colorado
Rainbow lakes, lower lake
40.01180
-105.578135
Elevation 2,098 m
Al Mousa M.
10 mm

Appendix 3. Location names, elevations, and water parameters of lakes sampled for the caddisflies of montane and alpine lakes (following Pennak 1969) in Boulder, Clear Creek, Gilpin, Grand, Jackson, Larimer, and Routt Counties, northern Colorado, USA. June-September 2019 and 2020**.**

Lake	**County**	**Elevation (m)**	**Sampling date**	**Conductivity uS/cm**	**pH**	**Salinity ppm**	**TDS ppm**	**Water Temp. (˚C)**
Red Rock Lake	Boulder	3,100	10-VII-2019	29.0	9.2	0	0.0220	17.0
Brainard Lake	Boulder	3,154	10-VII-2019	15.5	9.3	0	0.0118	13.8
Rainbow Lakes, L#1	Boulder	3,098	10-VII-2019	27.5	8.9	0	0.0188	23.0
Mud Lake	Boulder	2,552	16-VII-2019	10.5	9.1	0	0.0771	19.7
Delonde ponds	Boulder	2,602	16-VII-2019	NA				
Brainard Lake	Boulder	3,154	17-VII-2019	17.0	8.8	0	0.0118	11.1
Red Rock Lake	Boulder	3,100	17-VII-2019	30.0	8.9	0	0.0220	19.2
Long Lake	Boulder	3,212	17-VII-2019	11.0	9.1	0	0.0101	10.7
Gold Lake	Boulder	2,627	18-VII-2019	15.0	8.9	0	0.0127	14.3
Lake Eldora	Boulder	2,831	18-VII-2019	18.0	9.0	0	0.0130	13.2
Peterson Lake, Eldora	Boulder	2,823	18-VII-2019	19.1	8.9	0	0.0122	13.4
Rainbow Lakes, lower L.	Boulder	2,098	23-VII-2019	37.6	7.8	0	0.0272	19.7
Rainbow Lakes, middle L.	Boulder	3,110	23-VII-2019	31.5	8.2	0	0.0233	18.3
Rainbow Lakes, upper L.	Boulder	3,127	23-VII-2019	17.5	7.7	0	0.0154	11.4
Lost Lake	Boulder	2,985	14-VIII-2019	53.7	8.8	0	0.0357	19.7
Woodland Lake	Boulder	3,348	14-VIII-2019	19.1	9.6	0	0.0125	13.9
Jenny Lake	Boulder	3,332	15-VIII-2019	24.2	7.5	0	0.0159	11.8
Yankee Doodle Lake	Boulder	3,268	15-VIII-2019	53.7	8.8	0	0.0357	19.0
Red Rock Lake	Boulder	3,100	20-VIII-2019	30.2	9.5	0	0.0243	19.6
Brainard Lake	Boulder	3,154	20-VIII-2019	17.5	9.3	0	0.0121	17.2
Long Lake	Boulder	3,212	20-VIII-2019	17.0	8.9	0	0.0117	16.4
Lake Isabelle	Boulder	3,325	20-VIII-2019	14.7	8.7	0	0.0097	13.2
wetland, L. Isabelle Trail	Boulder	3,100	20-VIII-2019	17.7	8.8	0	0.0117	15.6
Crater Lakes, lower N.	Gilpin	3,230	08-VIII-2019	17.8	8.7	0	0.0122	16.0
Crater Lakes, lower S.	Gilpin	3,225	08-VIII-2019	18.1	8.7	0	0.0118	14.3
Crater Lakes, upper L.	Gilpin	3,357	08-VIII-2019	21.9	7.0	0	0.0125	13.1
Forest Lakes, upper L	Gilpin	3,308	08-VIII-2019	22.0	7.0	0	0.0125	14.0
Forest Lakes, upper L	Gilpin	3,308	15-VIII-2019	20.5	9.2	0	0.0137	15.7

Forest Lakes, lower L.	Gilpin	3,245	15-VIII-2019	15.3	8.6	0	0.0101	16.2
Forest Lakes, middle L.	Gilpin	3,257	15-VIII-2019	73.7	8.9	0	0.0487	14.7
Horseshoe Lake, Parshall	Grand	3,420	13-VIII-2019	16.2	8.9	0	0.0120	15.3
wetland, near Stone Lake	Grand	3,200	17-VIII-2019	14.3	9.3	0	0.0094	14.4
Stone Lake	Grand	3,240	17-VIII-2019	11.1	8.7	0	0.0072	14.2
Upper Lake	Grand	3,270	17-VIII-2019	16.7	9.9	0	0.0110	14.9
Lost Lake, FS456	Grand	2,943	21-IX-2019	25.3	8.6	0	0.0145	16.2
Watanga Lake	Grand	3,283	30-VIII-2019	23.3	9.4	0	0.0153	17.5
Strawberry Lake	Grand	2,800	30-VIII-2019	17.7	8.8	0	0.0117	15.6
Lost Lake, Co Rd 103	Larimer	2,835	21-VI-2019	48.6	9.2	0	0.0417	12.6
Creedmore Lakes, L#2	Larimer	2,542	09-VII-2019	53.1	8.8	0	0.0379	21.4
Lost Lake, Co Rd 103	Larimer	2,835	09-VII-2019	55.6	8.3	0	0.0471	21.2
Laramie Lake, Rd 103	Larimer	2,845	24-VII-2019	41.4	8.8	0	0.0294	20.8
Twin Lakes, East	Larimer	2,886	24-VII-2019	45.8	6.9	0	0.0323	19.1
Twin Lakes, North	Larimer	2,895	24-VII-2019	39.2	7.1	0	0.0229	19.3
Trap Lake	Larimer	3,030	24-VII-2019	32.4	9.1	0	0.0253	16.3
Peterson Lake	Larimer	2,896	30-VII-2019	19.2	7.4	0	0.0145	18.7
Lost Lake, Rawah Trail	Larimer	3,100	31-VII-2019	16.9	8.4	0	0.0122	18.8
Lily Pond Lake, Rd 103	Larimer	2,600	31-VII-2019	35.6	8.6	0	0.0232	20.9
Timberline Lake	Larimer	3,210	07-VIII-2019	19.4	9.7	0	0.0127	16.7
Browns Lake	Larimer	3,210	07-VIII-2019	19.3	9.3	0	0.0129	15.7
Comanche Lake	Larimer	3,043	07-VIII-2019	11.3	9.0	0	0.0074	17.9
Creedmore Lakes, L#2	Larimer	2,542	22-VIII-2019	53.1	8.8	0	0.0379	19.7
Creedmore Lakes, L#1	Larimer	2,533	22-VIII-2019	39.1	8.9	0	0.0352	20.2
Creedmore Lakes, L#3	Larimer	2,538	22-VIII-2019	38.2	8.8	0	0.0379	19.1
Emmaline Lake	Larimer	3,356	25-VIII-2019	11.4	9.5	0	0.0076	6.2
Cirque Lake	Larimer	3,334	25-VIII-2019	20.5	9.2	0	0.0135	9.1
Lost Lake, Co Rd 103	Larimer	2,835	02-IX-2019	51.3	9.2	0	0.0412	19.3
Trap Lake	Larimer	3,030	02-IX-2019	32.0	9.1	0	0.0245	18.2
Lily Pond Lake, Rd 103	Larimer	2,600	02-IX-2019	33.2	8.9	0	0.0417	19.0
Red Rock Lake	Boulder	3,100	09-VII-2020	32.6	7.4	0	0.0126	19.5
Brainard Lake	Boulder	3,154	09-VII-2020	17.3	7.6	0	0.0113	15.1
Lake Isabelle	Boulder	3,325	09-VII-2020	15.8	7.6	0	0.0104	10.7
Long Lake	Boulder	3,212	09-VII-2020	16.7	8.3	0	0.0110	12.0
Bob Lake	Boulder	3,525	11-VII-2020	16.2	9.2	0	0.0108	3.6

Betty Lake	Boulder	3,484	11-VII-2020	16.7	8.3	0	0.0111	11.8
King Lake	Boulder	3,482	11-VII-2020	13.0	6.5	0	0.0087	8.5
Diamond Lake	Boulder	3,342	17-VII-2020	25.1	7.6	0	0.0165	13.0
Upper Diamond Lake	Boulder	3,575	17-VII-2020	20.6	9.6	0	0.0128	7.2
Lost Lake, via Hessie Trail	Boulder	2,985	04-VIII-2020	52.1	8.7	0	0.0345	16.5
Mud Lake	Boulder	2,552	06-VII-2020	55.9	8.1	0	0.0352	17.1
pond, W of Mitchell Lake	Boulder	3,315	06-VIII-2020	NA				
Little Blue Lake	Boulder	3,616	06-VIII-2020	7.0	8.9	0	0.0046	9.9
Blue Lake	Boulder	3,460	06-VIII-2020	8.9	9.6	0	0.0059	11.0
Mitchell Lake	Boulder	3,268	06-VIII-2020	18.1	8.7	0	0.0117	15.2
Brainard Lake	Boulder	3,154	06-VIII-2020	43.1	9.1	0	0.0211	16.2
Red Rock Lake	Boulder	3,100	06-VIII-2020	58.2	8.8	0	0.0341	19.0
Rock Lake	Boulder	2,645	08-VIII-2020	NA				
Red Deer Lake	Boulder	3,164	08-VIII-2020	13.1	8.3	0	0.0086	13.7
Echo Lake	clear Creek	3,236	08-VII-2020	19.2	8.6	0	0.0744	16.7
Lake Quivira	clear Creek	3,152	08-VII-2020	18.2	7.6	0	0.0221	12.1
Silver Lake*	clear Creek	3,160	08-VII-2020	NA				
Saint Mary’s Lake	clear Creek	3,270	08-VII-2020	15.1	7.2	0	0.0521	10.2
Green Lake	clear Creek	3,026	15-VII-2020	89.9	8.6	0	0.0593	14.2
Clear Lake	clear Creek	3,003	15-VII-2020	92.1	8.5	0	0.0471	14.5
Echo Lake	clear Creek	3,236	15-VII-2020	47.0	8.6	0	0.0521	18.2
Snow Line Lake	Gilpin	2,744	23-VI-2020	NA				
Crater Lakes, lower L. N	Gilpin	3,230	24-VII-2020	17.5	8.7	0	0.0109	14.4
Crater Lakes, lower L. S	Gilpin	3,225	24-VII-2020	17.1	9.0	0	0.0113	14.3
Crater Lakes, upper L.	Gilpin	3,357	24-VII-2020	17.1	8.8	0	0.0121	12.7
Corona Lake	Grand	3,420	11-VII-2020	16.2	8.0	0	0.0112	12.3
Pumphouse Lake	Grand	3,460	11-VII-2020	15.3	8.1	0	0.0092	12.1
Monarch Lake	Grand	2,542	11-VII-2020	69.2	7.7	0	0.0654	18.3
Lake Agnes	Grand	2,675	18-VII-2020	NA				
Dumont Lake	Grand	2,900	18-VII-2020	41.3	8.1	0	0.0273	18.5
Lake Evelyn	Grand	3,395	19-VII-2020	32.7	9.1	0	0.0217	16.5
Muddy Pass Lake	Jackson	2,675	18-VII-2020	146.8	8.9	0.1	0.1058	20.5
Zimmerman Lake	Larimer	3,196	27-VI-2020	NA				
Blue Lake	Larimer	3,252	07-VII-2020	53.8	6.9	0	0.0328	16.1

Lost Lake, Co Rd 103	Larimer	2,835	07-VII-2020	64.8	6.8	0	0.0422	19.1
Creedmore Lakes, L#2	Larimer	2,542	09-VIII-2020	66.6	6.8	0	0.0442	20.0
Creedmore Lakes, L#1	Larimer	2,533	09-VIII-2020	196.2	6.9	0	0.0592	20.4
Creedmore Lakes, L#3	Larimer	2,538	09-VIII-2020	208.1	6.7	0	0.0621	20.3
Bellaire Lake	Larimer	2,636	09-VIII-2020	66.9	6.9	0.1	0.0452	19.9
Molly Lake	Larimer	2,513	09-VIII-2020	187.9	6.7	0.1	0.0533	20.3
Trap Lake, Long Draw Rd	Larimer	3,030	29-VII-2020	256.3	8.7	0	0.2345	18.3
Peterson Lake	Larimer	2,896	29-VII-2020	142.3	9.1	0	0.0769	19.0
Long Draw Reservoir	Larimer	3,080	29-VII-2020	NA				
Rawah Lakes, L#2	Larimer	3,273	13-VIII-2020	12.2	8.1	0	0.0081	15.6
Rawah Lakes, L#1	Larimer	3,260	13-VIII-2020	25.3	7.9	0	0.0122	17.2
pond off Rawah Trail	Larimer	2,918	13-VIII-2020	NA				
Upper Sandbar Lake	Larimer	3,262	13-VIII-2020	19.6	8.3	0	0.0129	17.0
Lower Sandbar Lake	Larimer	3,252	13-VIII-2020	45.3	7.9	0	0.0127	17.6
Camp Lake	Larimer	3,260	13-VIII-2020	57.1	8.2	0	0.0131	18.2
Big Rainbow Lake	Larimer	3,270	13-VIII-2020	14.9	8.3	0	0.0097	14.8

Appendix 4. Water parameters for the sampling sites for the caddisflies of montane and alpine lakes (following Pennak 1969) in Boulder, Clear Creek, Gilpin, Grand, Jackson, Larimer, and Routt Counties, northern Colorado, USA. June-September 2019 and 2020. Record source symbols are B 87, Bushnell et al. 1987; DER, Davide E. Ruiter Database; H 10, Heinold, 2010; R95, Ruiter 1995; R 99, Ruiter 1999; YW, Yammamoto and Wigggins 1964; Z 12, Zuellig et al. 2012; 2019-2020: 2019-2020 sampling seasons.

Latitude	Longitude	Location	County	Elevation m	Collector	Date	Specimens	Deposited	Records
Apataniidae									
Apatania zonella (Zetterstedt, 1840)									
40.2597	-105.6028	Chasm Lake, RMNF	Boulder	3,750	P. Opler	20-VII-1998	6f	DER & CSUC	DER, H10
40.2597	-105.6028	Chasm Lake, RMNF	Boulder	3,750	B. Heinold	23-VII-2007	2f	CSUC	DER, H 10, Z12
40.2597	-105.6028	Chasm Lake, RMNF	Boulder	3,750	B. Heinold	19-VII-2009	3f	CSUC	DER
40.2597	-105.6028	Chasm Lake, RMNF	Boulder	3,750	B. Heinold	22-VII-2015	6f	CSUC	DER
39.5986	-105.6417	Summit Lake, Mount Evans	Clear Creek	3,915	P. Opler	05-VII-1996	3f	DER	DER, H 10, Z12
Hydroptilidae									
Agraylea multipunctata Curtis, 1834									
40.081877	-105.541489	Red Rock Lake	Boulder	3,100	D.E Ruiter	8-VIII-2003	8m	DER	DER
39.88619	-105.5081	Snowline Lake	Gilpin	2,743	D.E Ruiter	13-VII-1982	15m 6 f	DER	DER, H 10, Z12
39.841	-105.456	2538 Golden Gate Canyon Rd, Hwy 46	Gilpin	2,670	B.B. Bartell	30-VI-2012	1f	CSUC	DER
40.611854	-105.848707	Lost Lake, near Cameron Pass	Larimer	2,835	D.E Ruiter	13-VII-2011	19m 4f	DER	DER
40.3072	-105.5406	Lily Lake, off Highway 7, RMNP	Larimer	2,720	B.C. Kondratieff	24-VIII-2012	31m 3f	CSUC	DER
40.1547	-106.8733	Eagle Rock Lake	Routt	2,510	D.E Ruiter	25-VIII-1991	2m	DER	DER
40.1547	-106.8733	Eagle Rock Lake	Routt	2,510	D.E Ruiter	23-VIII-1991	106m 10f	DER	DER
Oxyethira dualis Morton, 1905									

40.0819	-105.542	swamp, W. of Red Rock L.	Boulder	3,100	D.E. Ruiter	15-VIII-1981	1m	DER	DER
Leptoceridae									
Mystacides interjecta (Banks, 1914)									
40.081877	-105.541489	Red Rock Lake, W of Ward	Boulder	3,100	D.E. Ruiter	10-VII-1994	3m 2f 1p	DER	DER, H 10, Z12
40.0775	-105.5861	pond, W of Long L.	Boulder	3,200	D.E. Ruiter	29-VII-1994	2m	DER	DER, H 10, Z12
40.0775	-105.5861	pond, W of Long L.	Boulder	3,200	D.E. Ruiter	31-VII-1998	6m	DER	DER, H 10, Z12
40.081877	-105.541489	Red Rock Lake, W of Ward	Boulder	3,100	D.E. Ruiter	31-VII-1998	1m	DER	DER
40.081877	-105.541489	Red Rock Lake, Ward	Boulder	3,100	D.E. Ruiter	13-VII-1982	13m 1f 2 L	DER	DER
40.081877	-105.541489	Red Rock Lake, Ward	Boulder	3,100	Ruiter & Brooks	31-VII-2008	3m	KJER	DER
40.081877	-105.541489	Red Rock Lake, Ward	Boulder	3,100	M. Al Mousa	04-VII-2020	1m	CSUC	2019 - 2020
40.081877	-105.541489	Red Rock Lake, Ward	Boulder	3,100	M. Al Mousa	09-VII-2020	3m 6f	CSUC	2019 - 2020
40.081877	-105.541489	Red Rock Lake, Ward	Boulder	3,100	M. Al Mousa	09-VII-2020	1m 1f	CSUC	2019 - 2020
40.0775	-105.5861	pond, W of Long Lake	Boulder	3,200	Ruiter & Brooks	31-VII-2008	1f	DER	DER
39.88619	-105.5081	Snowline Lake	Gilpin	2,744	D.E. Ruiter	13-VII-1982	6m	DER	DER
39.916176	-105.662074	Forest Lakes, L#1	Gilpin	3,260	M. Al Mousa	15-VIII-2019	1m	CSUC	2019 - 2020
40.2444	-105.8139	Grand Lake	Grand	2,550	S.K.&S.G. Wells	10-VII-1989	1m 1f	MLBM	DER

40.38201	-106.62172	pond, near Muddy pass Lake	Grand	2,860	B. Kondratieff	09-VIII-2019	1m 2f	CSUC	2019 - 2020
40.386922	-106.587283	Muddy Pass Lake, 2 Mi. of Rabbit Ears Pass, Route40	Jackson	2,675	Kondratieff & S. Fitzgerald	18-VIII-1983	1m 4f	CSUC	DER
40.386922	-106.587283	Muddy Pass Lake	Jackson	2,675	M. Al Mousa	18-VII-2020	1m 2f	CSUC	2019 - 2020
40.386922	-106.587283	Muddy Pass Lake	Jackson	2,675	M. Al Mousa	18-VII-2020	1m 1f	CSUC	2019 - 2020
40.386922	-106.587283	Muddy Pass Lake	Jackson	2,675	M. Al Mousa	18-VII-2020	1m	CSUC	2019 - 2020
40.611854	-105.848707	Lost Lake	Larimer	2,835	H. Malicky	29-VII-1995	2m	Malicky	DER
40.611854	-105.848707	Lost Lake	Larimer	2,835	C. & O. Flint	29-VII-1995	1f	FLINT	DER
40.611854	-105.848707	Lost Lake	Larimer	2,835	B. Kondratieff & M. Al Mousa	24-VII-2019	1f	CSUC	2019 - 2020
40.611854	-105.848707	Lost Lake	Larimer	2,835	M. Al Mousa	07-VII-2020	1m 1f	CSUC	2019 - 2020
40.611854	-105.848707	Lost Lake	Larimer	2,835	Unknown	14-IX-2002		CSUC	DER, H10
40.611854	-105.848707	Lost Lake	Larimer	2,835	M. Al Mousa	07-VII-2020	90m 13 f	CSUC	2019 - 2020
40.617788	-105.839773	Laramie Lake	Larimer	2,846	B. Kondratieff &M. Al Mousa	24-VII-2019	2f	CSUC	2019 - 2020

40.557519	-105.815366	Trap Lake	Larimer	3,030	M. Al Mousa	29-VII-2020	2m	CSUC	2019 - 2020
40.557519	-105.815366	Trap Lake	Larimer	3,030	M. Al Mousa	30-VII-2019	2m	CSUC	2019 - 2020
40.6167	-105.634925	Meadow pond, Fall River	Larimer	2,604	Unknown	27-VII-1938		INHS	DER, H 10, Z12
40.40511	-105.62167	Sheep Lake	Larimer	2,595	Unknown	17-VII-1939			YW, DER, H 10, Z12
Mystacides longicornis (Linnaeus, 1758)									
40.40511	-105.62167	Sheep Lake	Larimer	2,595	Unknown	17-VII-1939			DER, H 10, Z12
Oecetis inconspicua (Walker, 1852)									
40.081877	-105.541489	Red Rock Lake, W of Ward	Boulder	3,100	D.E. Ruiter	10-VII-1994	4L 1 p	DER	DER, H 10, Z12
40.611854	-105.848707	Lost Lake	Larimer	2,835	H. Malicky	29-VII-1995	10m 10f	Malicky	DER, H 10, Z12
40.611854	-105.848707	Lost Lake	Larimer	2,835	C. & O. Flint	29-VII-1995	7m 4f	FLINT	DER, H 10, Z12
40.611854	-105.848707	Lost Lake	Larimer	2,835	Unknown	29-VII-1995		USNM	DER, H 10, Z12
Limnephilidae									
Anabolia bimaculata (Walker, 1852)									
40.081877	-105.541489	Red Rock Lake	Boulder	3,100	D.E. Ruiter	29-VII-1994	1m	DER	DER, H 10, Z12

39.91772	-105.66827	Forest Lakes	Gilpin	3,255	D. Rathke	02-VIII-1991	1m 2f	DER	DER, H 10, Z12
40.03914	-106.01023	Rd 55, 4.6 mi. SW Hwy40	Grand	2,633	T.S. Dickel	19-VIII-1992	1f	CSUC	DER
40.30656	-105.84317	Green Mountain Employee Area	Grand	2,670	P. Opler	30-VIII-1997	8m	CSUC	DER
40.2844	-105.84533	Harbison Picnic Area	Grand	2,650	P.Opler & E. Buckner	13-VIII-1995	1f	CSUC	DER
40.41213	-105.65313	Endo Valley	Larimer	2,642	P. Opler	30-VIII-1990	2m	CSUC	DER, H 10, Z12
40.31342	-105.64819	Bear Lake	Larimer	2,900	P. Opler	27-VIII-1994	1m	CSUC	DER, H 10, Z12
40.41213	-105.65313	Endo Valley	Larimer	2,615	D. Katz	07-VIII-1995	12m 3f	CSU/Flin t	DER, H 10, Z12
40.37287	-105.61421	Upper Beaver Meadows Trailhead	Larimer	2,570	Unknown	16-VIII-1995		CSUC	DER, H 10, Z12
40.37287	-105.61421	Upper Beaver Meadows Trailhead	Larimer	2,570	S. Simonson	15-VII-1997	1m	CSUC	DER, H 10, Z12
40.351902	-105.644585	Fern Lake Trailhead	Larimer	2,500	R.J. Muckenthel-er	14-VIII-1994	1m	DER	DER, H 10, Z12
40.612013	-105.848779	Lost Lake, near FS Rd190	Larimer	2,835	D.E. Ruiter	29-VII-1995	3m 2f	DER	DER, H 10, Z12
40.612013	-105.848779	Lost Lake	Larimer	2,835	C. & O. Flint	29-VII-1995	10m 3f 5p	FLINT	DER, H 10, Z12
40.38698	-106.5872	Rabbit Ears Pass	Routt	2,680	C.L. Remington	23-VII-1960	1m	Peapody Mus	DER
40.1547	-106.8733	Eagle Rock Lake	Routt	2,510	D.E. Ruiter	25-VIII-1991	1m	DER	DER

40.081877	-105.541489	Red Rock Lake	Boulder	3,100	D.E. Ruiter	29-VII-1994	1m	DER	DER, H 10, Z12
Asynarchus montanus (Banks, 1907)									
39.954186	-105.664461	Woodland Lake	Boulder	3,345	M. Al Mousa	14-VIII-2019	1m 4f	CSUC	2019 - 2020
39.916176	-105.662074	Forest Lakes, L#1	Gilpin	3,260	M. Al Mousa	15-VIII-2019	1m	CSUC	2019 - 2020
40.30656	-105.84317	Green Mountain Employee Area	Grand	2,670	P. Opler	30-VIII-1997	1m	CSUC	DER, R99
40.2844	-105.84533	Harbison Picnic Area	Grand	2,650	P. Opler & E. Buckner	29-VII-1995	1m	CSUC	DER, R99
40.3357	-105.8587	1.2 Mi. S. of Bowen Baker Trailhead	Grand	2,680	P. Opler	23-VII-1994	1m	DER	DER, R99
40.151977	-105.684858	Stone Lake	Grand	3,240	M. Al Mousa	17-VIII-2019	2f	CSUC	2019 - 2020
40.16564	-105.734199	Watanga Lake	Grand	3,285	M. Al Mousa	31-VIII-2019	1m 4f	CSUC	2019 - 2020
40.16564	-105.734199	Watanga Lake	Grand	3,285	M. Al Mousa	31-VIII-2019	2m 16f	CSUC	2019 - 2020
40.603386	-105.686374	Timberline Lake	Larimer	3,210	M. Al Mousa	31-VII-2019	1m	CSUC	2019 - 2020
Asynarchus nigriculus (Banks, 1908)									
39.949561	-105.681039	Betty Lake , via King Lake Trail	Boulder	3,485	M. Al Mousa	07-VII-2020	1f	CSUC	2019 - 2020
39.949561	-105.681039	Betty Lake , via King Lake Trail	Boulder	3,485	M. Al Mousa	07-VII-2020	1m	CSUC	2019 - 2020

39.949561	-105.681039	Betty Lake , via King Lake Trail	Boulder	3,485	M. Al Mousa	07-VII-2020	2f	CSUC	2019 - 2020
39.992807	-105.650347	Diamond Lake, off 4th of July Rd	Boulder	3,342	M. Al Mousa	17-VII-2020	3 m	CSUC	2019 - 2020
40.093663	-105.627118	Little Blue Lake, near Ward	Boulder	3,615	M. Al Mousa	06-VIII-2020	1f	CSUC	2019 - 2020
40.093663	-105.627118	Little Blue Lake, near Ward	Boulder	3,615	M. Al Mousa	06-VIII-2020	2f	CSUC	2019 - 2020
40.093663	-105.627118	Little Blue Lake, near Ward	Boulder	3,615	M. Al Mousa	06-VIII-2020	2f	CSUC	2019 - 2020
40.093663	-105.627118	Little Blue Lake, near Ward	Boulder	3,615	M. Al Mousa	06-VIII-2020	1f	CSUC	2019 - 2020
40.093663	-105.627118	Little Blue Lake, near Ward	Boulder	3,615	M. Al Mousa	06-VIII-2020	1f	CSUC	2019 - 2020
40.093663	-105.627118	Little Blue Lake, near Ward	Boulder	3,615	M. Al Mousa	06-VIII-2020	1m	CSUC	2019 - 2020
40.093663	-105.627118	Little Blue Lake, near Ward	Boulder	3,615	M. Al Mousa	06-VIII-2020	1m 1f	CSUC	2019 - 2020
40.093663	-105.627118	Little Blue Lake, near Ward	Boulder	3,615	M. Al Mousa	06-VIII-2020	2m	CSUC	2019 - 2020
40.143002	-105.610288	Red Deer Lake, off St Vrain Trail	Boulder	3,164	M. Al Mousa	08-VIII-2020	1m 1f	CSUC	2019 - 2020
40.143002	-105.610288	Red Deer Lake, off St Vrain Trail	Boulder	3,164	M. Al Mousa	08-VIII-2020	1m	CSUC	2019 - 2020

40.143002	-105.610288	Red Deer Lake, off St Vrain Trail	Boulder	3,164	M. Al Mousa	08-VIII-2020	1f	CSUC	2019 - 2020
39.991615	-105.673223	Upper Diamond Lake	Boulder	3,575	M. Al Mousa	17-VII-2020	3m	CSUC	2019 - 2020
39.991615	-105.673223	Upper Diamond Lake	Boulder	3,575	M. Al Mousa	17-VII-2020	1m 1f	CSUC	2019 - 2020
40.0321	-105.5359	Science Lodge	Boulder	2,895	H. Rodeck	03-VII-1936	1m	UoFC	DER, H10
40.0321	-105.5359	Science Lodge	Boulder	2,895	H. Rodeck	02-VIII-1936	1m	UoFC	DER, H 10, Z12
39.9901	-105.51617	Caribou, sphagnum bog	Boulder	2,550	C.L. Remington	12-VII-1949	1m	Peabody Mus	DER
40.05534	-105.62053	Green Lake #4	Boulder	3,563	S.C. Johonnett	18-VIII-1961	2m	CU-Museum	DER, Z12
40.05981	-105.617021	Niwot Ridge	Boulder	3,740	Unknown	18-VIII-1961		UCMC	DER, H 10, Z12
39.950345	-105.58131	Eldora	Boulder	2,680	Unknown	19-VIII-1953		PMNH	DER, H 10, Z12
40.07785	-105.57514	Brainard Lake	Boulder	3,154	R.R. Dreisbach	08-VIII-1950	1m 2f	U. of Mich.	DER
40.0819	-105.542	swamp, west of Red Rock Lake	Boulder	3,100	D.E. Ruiter	31-VII-1998	1m	DER	DER
40.07785	-105.57514	Brainard Lake	Boulder	3,154	J. Schurich	28-VIII-2011	1m	CSUC	DER
40.05121	-105.61392	Green Lake #3	Boulder	3,455	Bushnell et al.	14-VIII-1990		CSUC	B87
40.081877	-105.541489	Red Rock Lake	Boulder	3,100	Unknown	31-VII-1998	A	DER	DER, H 10, Z12

39.58519	-105.65848	Abyss Lake	Clear Creek	3,860	B. Wuerthele	06-IX-1999	1m,p	DER	DER, H 10, Z12
39.6052	-105.76043	Murray Lake	Clear Creek	3,695	C.P. Slater	03-VIII-1985	1m	CSUC	DER
39.5915	-105.74047	of Lower Square Top Lake	Clear Creek	3,680	B. Heinhold	12-VIII-2011	1m	CSUC	DER
39.91368	-105.49666	Lump Gulch	Gilpin	2,550	H. Rodeck	08-VIII-1934	1m	UCMC	DER, H 10, Z12
40.20889	-105.83504	Rangers Meadows, Shadow Mountain Dam, RMNP	Grand	2,545	P.A. Opler	29-VII-1995	2m	CSUC	DER
40.89599	-106.68254	Seven Lakes,	Jackson	3,277	M. Bishop	25-VIII-1984	2m 1f	D. Maclean	DER
40.48104	-105.90365	Lake Agnes	Jackson	3,250	D. Funk	02-VIII-1987	1m	CSUC	DER
40.43015	-105.76585	Gore Range Overlook, RMNP	Larimer	3,500	B. Wahle	25-VII-1976	1m 4L	Wahle	DER
40.29241	-105.65702	above the Loch,	Larimer	3,115	B.C. Kondratieff	24-VIII-1988	2m 1f	CSUC	DER
40.33678	-105.67631	Fern Lake	Larimer	2,990	S. Simonson	21-VIII-1996	1m	CSUC	DER
40.33678	-105.67631	Fern Lake	Larimer	2,990	S. Simonson	07-VIII-1996	1m	CSUC	DER, H 10, Z12
40.33678	-105.67631	Fern Lake	Larimer	2,990	S. Simonson	13-VIII-1998	1m	CSUC	DER, H 10, Z12
40.520578	-105.894432	nr Cameron Pass	Larimer	3,146	Unknown	09-VIII-1954	A	ESUW	H10
40.37287	-105.61421	Upper Beaver Meadows Trailhead	Larimer	2,570	Unknown	16-VIII-1995	A	CSUC	H10
40.37287	-105.61421	Upper Beaver Meadows Trailhead	Larimer	2,570	S. Simonson	22-VIII-1997	1m	CSUC	DER, H 10, Z12
40.692683	-105.940984	Big Rainbow Lake	Larimer	3,270	M. Al Mousa	13-VIII-2020	1m 1f	CSUC	2019 - 2020
Dicosmoecus atripes (Hagen, 1875)									

40.0321	-105.5359	Science Lodge, Ward	Boulder	2,895	C.L. Remington	16-VIII-1954	1m	Peabody Mus	DER
40.0321	-105.5359	Science Lodge, Ward	Boulder	2,895	C.L. Remington	26-VIII-1954	1m	Peabody Mus	DER, H 10, Z12
40.0321	-105.5359	Science Lodge, Ward	Boulder	2,895	Unknown	17-VIII-1954	1m	PMNH	DER, Z12
39.938927	-105.566623	Eldora	Boulder	2,830	Unknown	17-VIII-1953		PMNH	DER, H 10, Z12
40.20779	-105.56654	Wild Basin Trailhead, RMNP	Boulder	2,739	Unknown	31-VIII-1999	A	CSUC	DER, H 10, Z12
39.605078	-105.76044	Murray Lake	Clear Creek	3,705	Unknown	18-IX-1982		DERPC	DER, H 10, Z12
39.605078	-105.76044	Murray Lake	Clear Creek	3,705	Unknown	18-IX-1996		DERPC	DER
39.59084	-105.73984	Square Top Lake	Clear Creek	3,680	Unknown	20-VI-1996		DERPC	DER, H 10, Z12
40.37287	-105.61421	Upper Beaver Meadows Trailhead	Larimer	2,570	Unknown	03-X-1994		CSUC	DER, Z12
40.41213	-105.65313	Endo Valley	Larimer	2,615	Unknown	30-VIII-1990		CSUC	DER, H 10, Z12
40.393808	-105.655535	Hidden Valley Picnic Area,	Larimer	2,850	Unknown	14-VIII-1990		CSUC	DER, H 10, Z12
40.29241	-105.65702	above the Loch, RMNP	Larimer	3,115	Unknown	24-VIII-1980		CSUC	DER
Glyphopsyche irrorata (Fabricius, 1781)									
40.07785	-105.57514	Brainard Lake	Boulder	3,153	Unknown	28-IX-1986		CSUC	DER, H 10, Z12
40.07785	-105.57514	Brainard Lake	Boulder	3,153	Unknown	29-VI-1986		DERPC	DER, Z12

39.94971	-105.616419	Lost Lake	Boulder	2,985	Unknown	29-IX-1977		UCMC	DER, H 10, Z12
40.0777	-105.58647	west of Long Lake Trailhead, Ward	Boulder	3,210	Unknown	29-VI-1986	1p	DER	H10
40.081877	-105.541489	Red Rock Lake	Boulder	3,100	J.V. Ward	13-IX-1986	1p	DER	DER, Z12
40.20779	-105.56654	Wild Basin Trailhead, RMNP	Boulder	2,739	Opler & Buckner	04-VI-1999	1m	CSUC	DER, H 10, Z12
39.92402	-105.49942	Manchester Lake, near Rollins Ville	Gilpin	2,615	Proebstel	30-IX-1990	1f	CSUC	DER, H 10, Z12
40.360365	-105.604512	Moraine Park	Larimer	2,500	P. Opler	15-IV-1994		CSUC	DER, H 10, Z12
40.360365	-105.604512	Moraine Park	Larimer	2,500	Unknown	13-V-1994		CSUC	H10
40.41213	-105.65313	Endo Valley	Larimer	2,615	Unknown	06-IV-1991		CSUC	DER, H 10, Z12
40.611854	-105.848707	Lost Lake	Larimer	2,835	Unknown	29-VII-1995		USNM	DER, H 10, Z12
40.31342	-105.64819	Bear Lake	Larimer	2,900	D. Katz	10-VII-1995	1m 1f	CSUC	DER
40.41379	-105.65795	Endo Valley Picnic Area,	Larimer	2,627	P. Opler	08-V-1994	2m 1f	DER	DER
39.94971	-105.616419	Lost Lake	Larimer	2,835	C. & O. Flint	29-VII-1995	1m	USNM	H10
39.94971	-105.616419	Lost Lake	Larimer	2,835	C. & O. Flint	29-VII-1995	1m	FLINT	DER, Z12
Hesperophylax consimilis (Banks, 1900)									
40.41401	-105.81939	Lake Irene Picnic Area	Grand	3,250	Buckner, Opler & Muckenthaler	10-VII-1994	9m	CSU	DER

40.37287	-105.61421	Upper Beaver Meadows Trailhead	Larimer	2,570	Aknown	10-IX-1994	A	CSUC	DER, H 10, Z12
40.40419	-106.63005	Dumont Lake	Routt	2,900	W.G. Downs	05-VIII-1979	1m	DER	DER
Hesperophylax designatus (Walker, 1852)									
39.6001	-105.75347	Silver Dollar Lake	Clear Creek	3,635	C.P. Slater	02-VIII-1985	1m	CSUC	DER, H 10, Z12
39.91368	-105.49666	Lump Gulch	Gilpin	2,550	H.G. Rodeck	27-VIII-1954	1f	CU-Museum	DER, H 10, Z12
40.2844	-105.84533	Harbison Picnic Area	Grand	2,650	P. Opler	30-VIII-1997	1m	CSUC	DER
40.28785	-105.84198	Ranger Meadows, Shadow Mountain Dam,	Grand	2,550	P. Opler	29-VII-1995	2m	CSUC	DER
40.393808	-105.655535	Hidden Valley Picnic Area,	Larimer	2,850	P. Opler	02-VII-1990	1f	CSUC	DER, H 10, Z12
40.37287	-105.61421	Upper Beaver Meadows Trailhead	Larimer	2,570	P. Opler	27-VIII-1990	3f	CSUC	DER
40.31342	-105.64819	Bear Lake	Larimer	2,900	R.J. Muckenthal er	04-VIII-1994	1m	CSUC	DER, H 10, Z12
40.37287	-105.61421	Upper Beaver Meadows Trailhead, RMNP	Larimer	2,570	D. Katz	16-VIII-1995	1f	CSUC	DER
40.37287	-105.61421	Upper Beaver Meadows Trailhead	Larimer	2,570	S. Simonson	22-VIII-1997	1f	CSUC	DER, Z12
40.37287	-105.61421	Upper Beaver Meadows Trailhead	Larimer	2,570	S. Simonson	15-VII-1997	1f	CSUC	DER
40.400414	-105.663696	Trail Ridge Rd.	Larimer	3,200	Unknown	07-III-1990	A	CSUC	DER, H10
Hesperophylax magnus Banks, 1918									

40.33176	-105.67045	0.5 miles E of Fern Lake Trailhead	Larimer	3,155	P. Opler	23-VII-1993	1m	CSUC	DER
40.360365	-105.604512	Moraine Park, .8M E Fern Lake	Larimer	2,500	Unknown	23-VII-1989	A	DER	DER, H10
40.33678	-105.67631	Fern Lake	Larimer	2,990	S. Simonson	21-VIII-1996	1m	CSUC	DER, Z12
Hesperophylax occidentalis (Banks, 1908)									
40.0819	-105.542	swamp, W. of Red Rock Lake	Boulder	3,100	Unknown	31-VII-1998	A	DER	DER, H10
40.0819	-105.542	swamp, west of Red Rock Lake	Boulder	3,100	D.E. Ruiter	31-VII-1998	1m	DER	DER, Z12
40.05094	-105.6057	Green Lake, L1	Boulder	3,430	B87	no date			B87
40.04914	-105.61017	Green Lake, L2	Boulder	3,410	B87	no date			B87
40.05171	-105.616	Green Lake, L3	Boulder	3,455	B87	no date			
40.072535	-105.591939	Long Lake	Boulder	3,212	M. Al Mousa	09-VII-2020	13m	CSUC	2019 - 2020
40.072535	-105.591939	Long Lake	Boulder	3,212	M. Al Mousa	09-VII-2020	1m	CSUC	2019 - 2020
40.05527	-105.62047	Green Lake, L4	Boulder	3,565	B87	no date			B87
40.052301	-105.630512	Green Lake, L5	Boulder	3,620	B87	no date			B87
39.69175	-105.69792	Georgetown Reservoir	Clear Creek	2,815	D.E. Ruiter	10-VIII-1985	A 1L 2P	DER	DER, H 10, Z12
39.8174	-105.53428	Central City	Gilpin	2,665	Unknown	25-VII-1980		CSUC	DER, H 10, Z12
39.878871	-105.971152	Lake Evelyn	Grand	3,395	M. Al Mousa	19-VII-2020	1m 1f	CSUC	2019 - 2020
40.3357	-105.8587	1.2 Mi. S. of Bowen Baker Trailhead	Grand	2,680	Opler & Buckner	23-VII-1994	1m	CSUC	DER
40.2844	-105.84533	Harbison Picnic Area, RMNP	Grand	2,650	Opler & Buckner	13-VIII-1995	4f	CSUC	DER

40.20979	-105.83411	Ranger Meadows, Shadow Mountain Dam	Grand	2,545	P. Opler	29-VII-1995	2m	CSUC	DER
40.41401	-105.81939	Lake Irene Picnic Area	Grand	3,250	Opler & Buckner	18-VII-1998	2m 1f	CSUC	DER
40.155628	-105.681526	Upper Lake	Grand	3,270	M. Al Mousa	17-VIII-2019	1m	CSUC	2019 - 2020
40.155628	-105.681526	Upper Lake	Grand	3,270	M. Al Mousa	17-VIII-2019	2m 2f	CSUC	2019 - 2020
40.48104	-105.90365	Lake Agnes	Jackson	3,250	D. Funk	02-VIII-1987	1m	CSUC	DER
40.37287	-105.61421	Upper Beaver Meadows Picnic Area	Larimer	2,570	P. Opler	15-VI-1990	3m	CSUC	DER
40.39349	-105.65594	Hidden Valley Picnic Area	Larimer	2,865	P. Opler	02-VII-1990	1m 4f	CSUC	DER, H 10, Z12
40.41213	-105.65313	Endo Valley, RMNP	Larimer	2,615	P. Opler	30-VIII-1990	1F	CSUC	DER, H10
40.37287	-105.61421	Upper Beaver Meadows Trailhead	Larimer	2,570	P. Opler	27-VIII-1990	1F	CSUC	DER
40.37287	-105.61421	Upper Beaver Meadows Trailhead	Larimer	2,570	P. Opler	12-VII-1990	4M 4F	CSUC	DER, H10
40.41213	-105.65313	Endo Valley, RMNP	Larimer	2,615	P. Opler	13-VII-1993	3F	CSUC	DER, H 10, Z12
40.31342	-105.64819	Bear Lake	Larimer	2,900	R.J. Muckenthal er	04-VIII-1994	1F	CSUC	DER, H 10, Z12
40.37287	-105.61421	Upper Beaver Meadows Trailhead	Larimer	2,570	D. Katz	16-VIII-1995	2m 1f	CSUC	DER, H 10, Z12
40.37287	-105.61421	Upper Beaver Meadows Trailhead	Larimer	2,570	Buckner, Opler &	08-VII-1994	1m	CSUC	DER

					Muckenthal er				
40.33678	-105.67631	Fern Lake	Larimer	2,990	S. Simonson	17-IX-1998	2m	CSUC	DER
40.31342	-105.64819	Bear Lake	Larimer	2,900	D. Katz	10-VII-1995	3m 2f	CSUC	DEr
40.33678	-105.67631	Fern Lake	Larimer	2,990	S. Simonson	20-VII-1995	1m	CSUC	DER
40.37287	-105.61421	Upper Beaver Meadows Trailhead	Larimer	2,570	S. Simonson	15-VII-1997	1f	CSUC	DER
40.37287	-105.61421	Upper Beaver Meadows Trailhead	Larimer	2,570	S. Simonson	29-VII-1997	2m	CSUC	DER
Homophylax flavipennis Banks, 1900									
40.0321	-105.5359	Science Lodge	Boulder	2,895	Unknown	31-VIII-1939	A	CSUC	DER, H 10, Z12
40.0321	-105.5359	Science Lodge	Boulder	2,895	Rodeck, H.	06-VII-1936	1m	UofC	DER, H 10, Z12
40.0321	-105.5359	Science Lodge	Boulder	2,895	Rodeck, H.G.	27-VII-1938	1m	UofC	DER
40.20779	-105.56654	Wild Basin Trailhead,	Boulder	2,739	Unknown	31-VIII-1999		CSUC	DER, H 10, Z12
40.41401	-105.81939	Lake Irene Picnic Area	Grand	3,231	Unknown	24-VIII-1994		CSUC	DER, H 10, Z12
Lenarchus brevipennis (Banks, 1899)									
40.626098	-105.836016	drainage along Twin Lake Trail	Larimer	2,860	B. Kondratieff & M. Al Mousa	24-VII-2019	3m 1f	CSUC	2019 - 2020
Lenarchus fautini (Denning, 1949)									
40.072535	-105.591939	Long Lake	Boulder	3,210	M. Al Mousa	20-VIII-2019	1m 1f	CSUC	2019 - 2020
40.61322	-105.84493	bog NE of Lost Lake	Larimer	2,850	C. & O. Flint	29-VII-1995	1m	FLINT, USNM	DER, H 10, Z12

Limnephilus abbreviatus Banks, 1908									
39.9901	-105.51617	Caribou, sphagnum bog	Boulder	2,550	C.L. Remington	12-VII-1949	1m 1f	Peabody Mus	DER, R95, H10, Z12
40.0819	-105.542	swamp, west of Red Rock Lake	Boulder	3,100	D.E. Ruiter	22-VIII-1996	1m 4f	T.Vshivkova	DER
40.081877	-105.541489	Red Rock Lake	Boulder	3,100	D.E. Ruiter	22-VIII-1996	1m	DER	DER
40.077425	-105.58585	pond, W of Long L.	Boulder	3,210	D.E. Ruiter	22-VIII-1996	1m	DER	DER, H 10, Z12
40.0819	-105.542	swamp, west of Red Rock Lake	Boulder	3,100	D.E. Ruiter	31-VII-1998	10m 4f	T.Vshivkova	DER, H 10, Z12
40.0819	-105.542	swamp, west of Red Rock Lake	Boulder	3,100	D.E. Ruiter	23-IX-1999	1f	DER	DER
40.217082	-105.540085	2 miles E. of Wild Basin Trailhead	Boulder	2,539	P. Opler	31-VIII-1999	5m	CSUC	DER, H 10, Z12
40.0819	-105.542	swamp, W. of Red Rock L.	Boulder	3,100	D.E. Ruiter	15-VIII-1981	1m	DER	DER, H10
40.0321	-105.5359	0.5 Mi. W. of CU Mountain Research Station	Boulder	2,895	C. Verdone & D. Fuller	16-IX-2017	1f	CSUC	DER
39.95214	-105.59635	Hessie	Boulder	2,735	C.L. Remington	14-VIII-1953	1m	PM	DER, R95, H10, Z12
39.658306	-105.603522	Echo Lake	Clear Creek	3,240	D.E. Ruiter	30-VII-1998	1m	DER	DER, R95, H10, Z12
39.90858	-105.58701	Tolland, South Boulder Creek	Gilpin	2,705	C.L. Remington	11-VII-1949	1m	INHS	DER, H 10, Z12

40.41401	-105.81939	Lake Irene Picnic Area	Grand	3,250	P. Opler & E. Buckner	07-VIII-1992	2m 1f	CSUC	DER, R95
40.31253	-105.80897	Big Meadows, RMNP	Grand	2,860	B. Kondratieff	03-VIII-1988	1f	CSUC	DER, R95
40.33491	-105.85783	0.6 miles S. of Coyote Valley TH. RMNP	Grand	2,680	R.J. Muckenthal er	25-VIII-1994	3m	CSUC	DER
40.2844	-105.84533	Harbison Picnic Area	Grand	2,650	P. Opler & Simonson	29-VII-1995	6m 2f	CSUC	DER
40.2844	-105.84533	Harbison Picnic Area	Grand	2,650	P. Opler	30-IX-1997	12m 3f	CSUC	DER
40.30656	-105.84317	Green Mountain Employee Area	Grand	2,670	P. Opler	30-IX-1997	3m	CSUC	DER
40.38205	-106.62177	off County Road 15 (FR100), 0.25 Mi. off Hwy40	Grand	2,860	B. Kondratieff & A. Hall	15-VIII-2015	3m 4f	CSUC	DER
40.38205	-106.62177	pond at Forest Road 100 (CR19)	Grand	2,860	B. Kondratieff & A. Hall	15-VIII-2015	1m 1f	CSUC	DER
40.28785	-105.84198	Ranger Meadows, Shadow Mountain Dam, RMNP	Grand	2,550	P.A. Opler	29-VII-1995	1f	CSUC	DER
40.41401	-105.81939	Lake Irene Picnic Area	Grand	3,250	Unknown	24-VIII-1994	A	CSUC	DER, H 10, Z12
40.403815	-106.629774	Dumont Lake	Grand	2,900	M. Al Mousa	18-VII-2020	2m 2f	CSUC	2019 - 2020
40.386922	-106.587283	Muddy Pass Lake	Jackson	2,675	Kondratieff & S. Fitzgerald	18-VIII-1993	1f	CSUC	DER
40.52534	-106.03579	Gould, near Cameron Pass	Jackson	2,710	M.T. James	19-VIII-1940	1f	CSUC	DER
40.29241	-105.65702	the Loch, RMNP	Larimer	3,115	B.C. Kondratieff	02-VIII-1982	3m 2f	CSUC	DER

40.52045	-105.89388	Cameron Pass	Larimer	3,140	G.F. Knowlton	18-VIII-1940	1m 1f	INHS	DER, R95, H2010
40.52045	-105.89388	Cameron Pass, marsh puddles	Larimer	3,140	Ross & Delong	19-VIII-1954	1m 1f	INHS	DER, 1995
40.56107	-105.57931	Twin Lakes Reservoir	Larimer	2,840	M.K. Kroening	13-IX-1986	1f	CSUC	DER, 1995
40.24254	-105.533525	South Meeker Park	Larimer	2,625	B. Kondratieff	23-VI-1990	1f	CSUC	DER, R95
40.351902	-105.644585	Fern Lake Trailhead	Larimer	2,500	P.A. Opler	27-VIII-1994	3m	CSUC	DER, H10
40.351902	-105.644585	Fern Lake Trailhead	Larimer	2,500	S. Simonson	01-VIII-1996	1m 1f	CSUC	DER
40.351902	-105.644585	Fern Lake Trailhead	Larimer	2,500	S. Simonson	21-VIII-1996	1m	CSUC	DER, H 10, Z12
40.41213	-105.65313	Endo Valley Picnic Area	Larimer	2,615	P.A. Opler	07-X-1997	1f	CSUC	DER, H 10, Z12
40.37287	-105.61421	Upper Beaver Meadows Trailhead	Larimer	2,570	Unknown	22-VIII-1997	3m	CSUC	DER
40.37287	-105.61421	Upper Beaver Meadows Trailhead	Larimer	2,570	R.J. Muckenthaler	04-IX-1994	3m	CSUC	DER
40.351902	-105.644585	Fern Lake Trailhead	Larimer	2,500	S. Simonson	no date	1m	CSUC	DER
40.37287	-105.61421	Upper Beaver Meadows Trailhead	Larimer	2,570	S. Simonson	16-VIII-1995	3m 1f	CSUC	DER, H 10, Z12
40.351902	-105.644585	Fern Lake Trailhead	Larimer	2,500	S. Simonson	22-VII-1998	1f	CSUC	DER
40.56533	-105.58738	Pingree Park	Larimer	2,795	C.W. Sabrosky	14-VIII-1934	1f	INHS	DER, R95 H2010
40.56533	-105.58738	Pingree Park	Larimer	2,795	H.C. Severin	20-VIII-1925	1f	INHS	DER, R95,

									H2010
40.29241	-105.65702	the Loch, RMNP	Larimer	3,115	B.C. Kondratieff	02-VIII-1988	1m	CSUC	DER, R95, H2010
40.29241	-105.65702	the Loch, RMNP	Larimer	3,115	B.C. Kondratieff	24-VIII-1988	2m 2f	CSUC	DER, R95, H10, Z12
40.602946	-105.683186	Browns Lake	Larimer	3,210	M. Al Mousa	07-VIII-2019	2m 1f	CSUC	2019-2020
40.603386	-105.686374	Timberline Lake	Larimer	3,210	M. Al Mousa	07-VIII-2019	2m 4f	CSUC	2019-2020
40.697928	-105.939694	swamp, Rawah Trail	Larimer	3,215	M. Al Mousa	13-VIII-2020	1 m	CSUC	2019-2020
40.37508	-106.73119	Route40, 0.5 miles west of Meadows CG	Routt	2,820	Diez	03-IX-2000	1f	CSUC	DER
Limnephilus castor Ross & Merkley, 1952									
40.2844	-105.84533	Harbison Picnic Area	Grand	2,650	Opler & Buckner	30-VIII-1997	2m	CSUC	DER
40.37287	-105.61421	Upper Beaver Meadows Trailhead	Larimer	2,570	Unknown	16-VIII-1995	A	CSUC	DER, H 10, Z12
40.37287	-105.61421	Upper Beaver Meadows Trailhead	Larimer	2,570	P.A. Opler	27-VIII-1990	1f	CSUC	DER, R95
40.34169	-105.60523	Hollowell Park, RMNP	Larimer	2,555	R.J. Muckenthaler	06-VIII-1994	2m	CSUC	DER, H 10, Z12
40.37363	-106.73562	ponds south side of Route40, 0.5 Mi. W of Meadows CG	Routt	2,830	Diez	03-IX-2000	1f	CSUC	DER

Limnephilus coloradensis (Banks, 1899)									
40.0321	-105.5359	Science Lodge, Ward	Boulder	2,895	L. McCasky	31-VII-1939	1f	INHS	DER, R95, H10, Z12
40.0819	-105.542	swamp, W of Red Rock L	Boulder	3,100	D.E Ruiter	15-VIII-1981	12m 8f	DER	DER, R95, H 2010
40.0819	-105.542	swamp, W of Red Rock L	Boulder	3,100	D.E Ruiter	22-VIII-1996	7m 17f	DER	DER
40.0819	-105.542	swamp, W of Red Rock L	Boulder	3,100	D.E Ruiter	31-VII-1998	1f	DER	DER
40.0819	-105.542	swamp, W of Red Rock L.	Boulder	3,100	D.E Ruiter	08-VIII-2003	1m	DER	DER, Z12
40.081877	-105.541489	Red Rock Lake	Boulder	3,100	Unknown	07-VIII-1984		CSUC	DER, H10, Z12
40.42061	-105.81152	Milner Pass, RMNP	Grand	3,280	U.N. Lanham	22-VIII-1939	1f	INHS	DER, R95
40.41401	-105.81939	Lake Irene Picnic Area	Grand	3,250	E. Buckner & P. Opler	07-VIII-1992	55m 18f	CSUC	DER, R95
40.50188	-105.96742	4-H camp, Route 14, 4 miles SE of Gould	Jackson	2,830	P.H. Freytag	12-VIII-1955	3m 1f	UofWy-oming	DER, R95
40.56533	-105.58738	Pingree Park	Larimer	2,795	Beamer & Lawson	00-VIII-1925	1m	Snow Mus	DER
40.29241	-105.65702	above the Loch, RMNP	Larimer	3,115	B.C. Kondratieff	24-VIII-1988	3m 1f	CSUC	DER, R95
40.51997	-105.89285	Summit of Cameron Pass	Larimer	3,135	G.F. Knowlton	21-VIII-1940	1m	INHS	DER, R95, H 2010
40.56533	-105.58738	Pingree Park	Larimer	2,795	C.J. Sorenson	19-VIII-1935	1m	INHS	DER, R95, H10, Z12

40.56533	-105.58738	Pingree Park	Larimer	2,795	H.C. Severin	20-VIII-1925	1f	INHS	DER, R95, H2010
40.62121	-105.84762	wetland near Laramie Lake	Larimer	2,835	B.C. Kondratieff	24-VII-2019	2m	CSUC	DER
40.46841	-105.6334	Lawn Lake delta, RMNP	Larimer	3,345	B.C. Kondratieff	15-VII-2001	2m	CSUC	DER, H 10, Z12
40.691754	-105.946088	Upper Sandbar Lake	Larimer	3,262	M. Al Mousa	13-VIII-2020	47m	CSUC	2019 - 2020
40.691754	-105.946088	Upper Sandbar Lake	Larimer	3,262	M. Al Mousa	13-VIII-2020	2m	CSUC	2019 - 2020
40.691754	-105.946088	Upper Sandbar Lake	Larimer	3,262	M. Al Mousa	13-VIII-2020	1m	CSUC	2019 - 2020
40.697928	-105.939694	swamp, W of Red Rock L.	Larimer	3,215	M. Al Mousa	13-VIII-2020	2m 12f	CSUC	2019 - 2020
Limnephilus dispar McLachlan, 1875									
40.08191	-105.54202	swamp, W of Red Rock L	Boulder	3,100	D.E. Ruiter	13-VII-1982	1f	DER	DER, R95, H10, Z12
40.08191	-105.54202	swamp, W of Red Rock L	Boulder	3,100	D.E. Ruiter	08-VIII-2003	1f	DER	DER, H 10, Z12
40.08191	-105.54202	swamp, W of Red Rock L	Boulder	3,100	D.E. Ruiter	07-VII-1984	16m 8f	DER	DER, R95
Limnephilus diversus (Banks, 1903)									
40.34169	-105.53717	2 miles east of Wild Basin Trailhead	Boulder	2,625	P. Opler	31-VIII-1999	1M 1F	CSUC	DER, H 10, Z12

40.38205	-106.62177	small lake, at Forest Road 100 (CR19)	Grand	2,860	B. Kondratieff	15-VIII-2015	1f	CSUC	DER
40.39349	-105.65594	Mummy Pass Trail, 10.4 Km from Pingree Park	Larimer	3,360	Unknown	29-VII-2002	A	CSUC	DER, H 10, Z12
40.39349	-105.65594	Mummy Pass Trail, 10.4 Km from Pingree Park	Larimer	3,360	Unknown	25-VIII-2002	A	CSUC	DER, H 10, Z12
40.393808	-105.655535	Hidden Valley Picnic Area, RMNP	Larimer	2,850	Unknown	13-X-1991	A	DER	DER, R95, H10, Z12
40.39349	-105.65594	Hidden Valley Picnic Area, RMNP	Larimer	2,865	P. Opler	02-VII-1990	1m	CSUC	DER
Limnephilus externus Hagen, 1861									
40.012185	-105.581107	Rainbow Lakes, L#2	Boulder	3,110	M. Al Mousa	23-VII-2019	1m	CSUC	2019 - 2020
40.012185	-105.581107	Rainbow Lakes, L#2	Boulder	3,110	M. Al Mousa	23-VII-2019	1m	CSUC	2019 - 2020
40.012185	-105.581107	Rainbow Lakes, L#2	Boulder	3,110	M. Al Mousa	23-VII-2019	2f	CSUC	2019 - 2020
40.012185	-105.581107	Rainbow Lakes, L#2	Boulder	3,110	M. Al Mousa	23-VII-2019	1f	CSUC	2019 - 2020
40.012185	-105.581107	Rainbow Lakes, L#2	Boulder	3,110	M. Al Mousa	23-VII-2019	1m	CSUC	2019 - 2020
40.012185	-105.581107	Rainbow Lakes, L#2	Boulder	3,110	M. Al Mousa	23-VII-2019	1m	CSUC	2019 - 2020
40.012185	-105.581107	Rainbow Lakes, L#2	Boulder	3,110	M. Al Mousa	23-VII-2019	1f	CSUC	2019 - 2020

40.011842	-105.578139	Rainbow Lakes, L#1	Boulder	2,098	M. Al Mousa	23-VII-2019	2f	CSUC	2019 - 2020
40.081877	-105.541489	Red Rock Lake	Boulder	3,100	A. Law	28-IX-1986	1f	CSUC	DER, R95, H 2010
40.081877	-105.541489	Red Rock Lake	Boulder	3,100	M. Al Mousa	10-VII-2019	3f	CSUC	2019 - 2020
40.081877	-105.541489	Red Rock Lake	Boulder	3,100	D.E. Ruiter	22-IX-1996	1f	DER	DER
40.081877	-105.541489	Red Rock Lake	Boulder	3,100	Unknown	12-IX-1988	A	CSUC	H 2010
40.081877	-105.541489	Red Rock Lake	Boulder	3,100	Stone & Monroe	19-IX-1998	1f	CSUC	DER, Z12
40.2058	-105.52838	2 miles E. of Wild Basin Trailhead	Boulder	2,580	P. Opler	31-VIII-1999	2m	CSUC	DER, H10
40.081877	-105.541489	Red Rock Lake	Boulder	3,100	D.E. Ruiter	15-VIII-1981	1m 1f	T.Vshivk ova	DER
40.069053	-105.585555	of Rainbow Lakes	Boulder	3,090	D.E. Ruiter	16-VII-1982	8 L	J. Hodges	DER
40.081877	-105.541489	Red Rock Lake	Boulder	3,100	Unknown	19-IX-1988		CSUC	DER
40.21876	-105.53718	2 Mi. E of Wild Basin Trailhead	Boulder	2,540	Unknown	31-VIII-1999		CSUC	DER, Z12
40.31253	-105.80897	Big Meadows, RMNP	Grand	2,860	B.C. Kondratieff	03-VIII-1988	1m	CSUC	DER, R95
40.33491	-105.85783	0.6 miles S. of Coyote Valley Trailhead, RMNP	Grand	2,680	R.J. Muckenthal er	25-VIII-1994	1m	CSUC	DER
40.2844	-105.84533	Harbison Picnic Area	Grand	2,650	Opler & Buckner	13-VIII-1995	1f	CSUC	DER
40.30656	-105.84317	Green Mountain Employee Area	Grand	2,670	P. Opler	30-VIII-1997	4m 5f	CSUC	DER
40.2844	-105.84533	Harbison Picnic Area	Grand	2,650	P. Opler	30-VIII-1997	5m 9f	CSUC	DER

40.2844	-105.84533	Harbison Picnic Area	Grand	2,650	Opler & Buckner	11-VIII-1997	1f	CSUC	DER
40.38205	-106.62177	off County Road 15 (FR100), 0.25 Mi. off Hwy40	Grand	2,860	B.C. Kondratieff	07-VIII-2014	1m 3f	CSUC	DER
40.38205	-106.62177	off County Road 15 (FR100), 0.25 Mi. off Hwy40	Grand	2,860	B.C. Kondratieff	15-VIII-2015	1f	CSUC	DER
40.38205	-106.62177	off County Road 15 (FR100), 0.25 Mi. off Hwy40	Grand	2,860	Kondratieff & A. Hall	15-VIII-2015	2m 2f	CSUC	DER
40.403815	-106.629774	Dumont Lake	Grand	2,900	M. Al Mousa	18-VII-2020	1m	CSUC	2019 - 2020
40.403815	-106.629774	Dumont Lake	Grand	2,900	M. Al Mousa	18-VII-2020	1m	CSUC	2019 - 2020
40.403815	-106.629774	Dumont Lake	Grand	2,900	M. Al Mousa	18-VII-2020	1m	CSUC	2019 - 2020
40.9295	-106.61005	Big Creek Lake	Jackson	2,745	W.D. Downs	25-VIII-1979	1m	DER	DER, R95
40.611854	-105.848707	Lost Lake, Rd103	Larimer	2,835	J.P. McKee	21-IX-1988	1f	CSUC	DER, H 10, Z12
40.41213	-105.65313	Endo Valley Picnic Area	Larimer	2,615	P. Opler	30-VIII-1990	1m 2f	CSUC	DER, R95
40.31342	-105.64819	Bear Lake	Larimer	2,900	R.J. Muckenthaler	04-VIII-1994	1m	CSUC	DER, H10
40.351902	-105.644585	Fern Lake Trailhead, RMNP	Larimer	2,500	P. Opler	27-VIII-1994	1m 1f	CSUC	DER, H 10, Z12
40.31342	-105.64819	Bear Lake	Larimer	2,900	P. Opler	27-VIII-1994	4m 4f	CSUC	DER, H 10, Z12

40.351902	-105.644585	Fern Lake Trailhead	Larimer	2,500	R.J. Muckenthal er	03-IX-1994	1f	CSUC	DER, H 10, Z12
40.41213	-105.65313	Endo Valley Picnic Area	Larimer	2,615	P. Opler	07-X-1997	3m 1f	CSUC	DER, H 10, Z12
40.30711	-105.54044	Lily Lake, off Hwy7, RMNP	Larimer	2,720	B.C. Kondratieff	24-VIII-2012	2m 2f	CSUC	DER
40.611854	-105.848707	Lost Lake, Rd103	Larimer	2,835	M. Al Mousa	02-IX-2019	2m 3f	CSUC	2019 - 2020
40.557519	-105.815366	Trap Lake	Larimer	3,030	M. Al Mousa	31-VII-2019	4f	CSUC	2019 - 2020
40.557519	-105.815366	Trap Lake	Larimer	3,030	M. Al Mousa	31-VII-2019	2m 1f	CSUC	2019 - 2020
40.15483	-106.87337	Eagle Rock Lake	Routt	2,510	D.E. Ruiter	23-VIII-1991	2f	DER	DER
Limnephilus hyalinus Hagen, 1861									
40.081877	-105.541489	Red Rock Lake	Boulder	3,100	M. Al Mousa	04-VII-2020	1m	CSUC	2019 - 2020
40.081877	-105.541489	Red Rock Lake	Boulder	3,100	Stone & Monore	19-IX-1998	1m	CSUC	DER, H 10, Z12
40.28415	-105.84563	Lake, near Green Mountain Trailhead	Grand	2,650	B.C. Kondratieff	08-X-1999	1m	CSUC	DER, R95
40.2844	-105.84533	Harbison Picnic Area	Grand	2,650	Opler & Buckner	13-VIII-1995	1m	CSUC	DER
40.38205	-106.62177	off County Road 15 (FR100), 0.25 Mi. off Hwy40	Grand	2,860	B.C. Kondratieff	07-VIII-2014	8m 3f	CSUC	DER
40.38205	-106.62177	off County Road 15 (FR100), 0.25 Mi. off Hwy40	Grand	2,860	B.C. Kondratieff	15-VIII-2015	18m 17f	CSUC	DER

40.9295	-106.61005	Big Creek Lake	Jackson	2,745	W.G. Downs	25-VIII-1979	26m 11f	DER	DER, R95
40.9295	-106.61005	Big Creek Lake	Jackson	2,745	W.G. Downs	25-VIII-1979	22m 10f	DER	DER, R95
40.56533	-105.58738	Pingree Park	Larimer	2,795	C.W. Sabrosky	14-VIII-1934	1m	USNM	DER, H 10, Z12
40.862572	-105.586196	Creedmore Lakes, Lake 2	Larimer	2,540	M. Al Mousa	22-VIII-2019	1m	CSUC	2019 - 2020
40.30711	-105.54044	Lily Lake, off Hwy7, RMNP	Larimer	2,720	B.C. Kondratieff	24-VIII-2012	3f	CSUC	DER
Limnephilus indivisus Walker, 1852									
40.217082	-105.540085	2 miles E. of Wild Basin Trailhead	Boulder	2,539	P. Opler	31 -VIII-1999	2m	CSUC	DER, H 10, Z12
40.31315	-105.80903	Big Meadows, RMNP	Grand	2,865	B. Kondratieff	03-VIII-1988	1m	CSUC	DER
40.2844	-105.84533	Harbison Picnic Area	Grand	2,650	Opler & Buckner	29-VII-1995	1m	CSUC	DER
40.2844	-105.84533	Harbison Picnic Area	Grand	2,650	Opler & Buckner	30-VIII-1997	1f	CSUC	DER
40.50941	-106.03418	Gould	Jackson	2,740	H.M. Harris	28-VIII-1941	1f	INHS	DER, R95
40.52045	-105.89388	Cameron Pass	Larimer	3,140	R.H. Ross	19-VIII-1941	2f	INHS	DER, R95
40.41213	-105.65313	Endo Valley Picnic Area	Larimer	2,615	P. Opler	30-VIII-1990	1f	CSUC	DER, H 10, Z12
40.56533	-105.58738	Pingree Park	Larimer	2,795	C.W. Sabrosky	14-VIII-1934	2f	INHS	DER, H 10, Z12
40.56533	-105.58738	Pingree Park	Larimer	2,795	C.J. Drake	20-VIII-1923	1f	INHS	DER, R95, H10, Z12

40.351902	-105.644585	Fern Lake Trailhead	Larimer	2,500	R.J. Muckenthaler	04-IX-1994	1m	CSUC	DER, H 10, Z12
40.611854	-105.848707	Lost Lake, Rd103	Larimer	2,835	Unknown	29-VII-1995	L P	USNM	DER, H10
40.611854	-105.848707	Lost Lake, Rd103	Larimer	2,835	S. Simonson	21-VIII-1996	1m	CSUC	DER
40.351902	-105.644585	Fern Lake Trailhead	Larimer	2,500	S. Simonson	21-VIII-1996	1m	CSUC	DER
40.351902	-105.644585	Fern Lake Trailhead	Larimer	2,500	D. Kataz	15-VII-1995	1m 1f	CSUC	DER
40.351902	-105.644585	Fern Lake Trailhead	Larimer	2,500	S. Simonson	13-VIII-1998	1m	CSUC	DER, H10
40.634999	-105.833844	Twin Lakes, N of Laramie L.	Larimer	2,886	B. Kondratieff	24-VII-2019	2m	CSUC	2019 - 2020
40.33678	-105.67631	Fern Lake, RMNP	Larimer	2,990	S. Simonson	20-VII-1995	4m 2f	CSUC	DER
Limnephilus janus Ross, 1938									
40.0777	-105.58647	pond, W of Long L.	Boulder	3,210	D.E Ruiter	29-VII-1994	1m 1f 1L	DER	DER, H10
40.0777	-105.58647	pond, W of Long L.	Boulder	3,210	D.E Ruiter	31-VII-1998	1m	DER	DER, H 10, Z12
40.081877	-105.541489	Red Rock Lake	Boulder	3,100	D.E Ruiter	15-VIII-1981	1f 1L 2P	DER	DER, H 10, Z12
40.0819	-105.542	swamp, west of Red Rock Lake	Boulder	3,100	D.E Ruiter	15-VIII-1981	1f	DER	DER
40.081877	-105.541489	Red Rock Lake	Boulder	3,100	D.E Ruiter	09-VIII-1981	2p	DER	DER
39.954369	-105.665083	Woodland Lake	Boulder	3,345	Unknown	26-VII-1939	A	INHS	H 2010
39.907704	-105.587494	Tolland	Gilpin	2,705	Banks	00-000-1924			H 2010, Z 2012
40.24469	-105.81318	Grand Lake	Grand	2,550	H.H. Ross	24-VII-1938	2p	INHS	DER
40.929965	-106.61007	Big Creek Lake	Jackson	2,745	W.G. Downs	25-VIII-1979	1m 3f	DER	DER, R 95

40.386922	-106.587283	Muddy Pass Lake	Jackson	2,675	Kondratieff & S. Fitzgerald	18-VIII-1993	5m 4f	CSUC	DER, R 95
40.634999	-105.833844	Twin Lakes	Larimer	2,885	M. Al Mousa	24-VII-2019	1m	CSUC	2019 - 2020
40.617788	-105.839773	Laramie Lake	Larimer	2,845	M. Al Mousa	24-VII-2019	11m 7f	CSUC	2019 - 2020
40.41213	-105.65313	Endo Valley Picnic Area	Larimer	2,640	Unknown	13-VII-1993	A	CSUC	DER, H10
40.73378	-105.90339	pond off Rawah Trail	Larimer	2,918	M. Al Mousa	13-VIII-2020	1m 2f	CSUC	2019 - 2020
40.611854	-105.848707	Lost Lake, Rd103	Larimer	2,835	M. Al Mousa	02-IX-2019	4m 1f	CSUC	2019 - 2020
40.611854	-105.848707	Lost Lake, Rd103	Larimer	2,835	B.C. Kondratieff	08-VIII-2011	2m 3f	CSUC	DER
40.15483	-106.87337	Eagle Rock Lake	Routt	2,510	D.E Ruiter	23-VIII-1991	2m 1f	DER	DER
Limnephilus labus Ross, 1941									
39.954369	-105.665083	Woodland Lake	Boulder	3,345	Unknown	26-VII-1941	A	INHS	H 2010, Z 2012
39.907704	-105.587494	Tolland	Gilpin	2,705	Unknown	25-VIII-1998	A	INHS	H 2010, Z 2012
Limnephilus moestus Banks, 1908									
40.0819	-105.542	swamp, west of Red Rock Lake	Boulder	3,100	D.E Ruiter	10-VII-1994	1m 2f	DER	DER, H 10, Z12
40.081877	-105.541489	Red Rock Lake	Boulder	3,100	D.E Ruiter	31-VII-1998	1m 2f	DER	DER, H 10, Z12

40.2058	-105.52838	3.2 miles E. of Wild Basin Trailhead	Boulder	2,580	P. Opler	31-VIII-1999	1m	CSUC	DER, H 10, Z12
40.413	-105.824	Lake Irene Campground	Grand	3,255	Opler & Buckner	07-VIII-1992	1f	CSUC	DER, R95
40.413	-105.824	Lake Irene Campground	Grand	3,255	P. Opler	09-VII-1994	26m	CSUC	DER
40.413	-105.824	Lake Irene Campground	Grand	3,255	Opler & Buckner	18-VII-1998	14m	CSUC	DER
40.413	-105.824	Lake Irene Campground	Grand	3,255	Opler & Buckner	10-VII-1994	10m	CSUC	DER
40.413	-105.824	Lake Irene Campground	Grand	3,255	Unknown	24-VIII-1994	A	CSUC	DER, H10
40.34	-105.683	0.6 miles south of Coyote Valley Trailhead, RMNP	Grand	2,680	R.J. Muckenthal er	25-VIII-1995	1m	CSUC	DER
40.2844	-105.84533	Harbison Picnic Area	Grand	2,650	Opler & Buckner	11-VIII-1995	1m	CSUC	DER
40.38205	-106.62177	off County Road 15 (FR100), 0.25 Mi. off Hwy40	Grand	2,860	Kondratieff &Hall	15-VIII-2015	1f	CSUC	DER
40.413	-105.824	Lake Irene Campground	Grand	3,255	R.J. Muckenthal er	24-VIII-1994	8m	CSUC	DER, H 10, Z12
40.393808	-105.655535	Hidden Valley Picnic Area, RMNP	Larimer	2,850	Unknown	25-VII-1938	A	CSUC	DER, H 10, Z12
40.313	-105.649	Bear Lake SW, RMNP	Larimer	2,895	Unknown	08-IV-1994	A	CSUC	Z12
40.313	-105.649	Bear Lake SW, RMNP	Larimer	2,895	R.J. Muckenthal er	04-VIII-1994	3m	CSUC	DER, H10
40.29241	-105.65702	the Loch, RMNP	Larimer	3,115	B.C. Kondratieff	24-VIII-1988	1f	CSUC	DER, H10

40.691754	-105.946088	Upper Sandbar Lake	Larimer	3,262	M. Al Mousa	13-VIII-2020	1m 1f	CSUC	2019 - 2020
Limnephilus perpusillus Walker, 1852									
40.0819	-105.542	swamp, west of Red Rock Lake	Boulder	3,100	D.E. Ruiter	22-VIII-1996	1f	DER	DER
40.0819	-105.542	swamp, west of Red Rock Lake	Boulder	3,100	D.E. Ruiter	07-VII-1984	13m 3f	DER	DER, R 95
40.0819	-105.542	swamp, west of Red Rock Lake	Boulder	3,100	D.E. Ruiter	31-VII-1998	72m 40f	DER	DER
40.0819	-105.542	swamp, west of Red Rock Lake	Boulder	3,100	D.E. Ruiter	31-VII-1998	72m 40f	DER	DER, Z12
40.0819	-105.542	swamp, west of Red Rock Lake	Boulder	3,100	Unknown	08-VIII-2003		DER	H 2010
40.0819	-105.542	swamp, west of Red Rock Lake	Boulder	3,100	D.E. Ruiter	15-VIII-1981	5m 6f	DER	DER, H10
Limnephilus picturatus McLachlan, 1875									
40.072535	-105.591939	Long Lake, W of Brainard Lake	Boulder	3,210	T. Cockerell	28-VIII-1900	2m 2f	UC	DER, R95
40.072535	-105.591939	Long Lake, W of Brainard Lake	Boulder	3,210	M. Al Mousa	20-VIII-2019	3m	CSUC	2019 - 2020
40.069053	-105.619198	Lake Isabelle	Boulder	3,325	R. Phillips	07-VIII-1939	1m	UofC	DER, R 95, Z 2012
39.954186	-105.664461	Woodland Lake	Boulder	3,347	M. Al Mousa	14-VIII-2019	2m	CSUC	2019 - 2020
40.0819	-105.542	swamp, west of Red Rock Lake	Boulder	3,100	D.E. Ruiter	10-VII-1994	17m 8f	DER	DER, H10
40.0777	-105.58647	pond, W of Long L.	Boulder	3,210	D.E. Ruiter	29-VII-1994	19m 24f	DER	DER, Z12
40.07296	-105.592	Long Lake, W of Brainard Lake	Boulder	3,210	D.E. Ruiter	29-VII-1994	1m 1f	DER	DER, H10

40.0819	-105.542	swamp, west of Red Rock Lake	Boulder	3,100	D.E. Ruiter	22-VIII-1996	34m 48f	DER	DER
40.0819	-105.542	swamp, west of Red Rock Lake	Boulder	3,100	D.E. Ruiter	31-VII-1998	40m 9f	DER	DER
40.0819	-105.542	swamp, west of Red Rock Lake	Boulder	3,100	D.E. Ruiter	15-VIII-1981	11m 10f	DER	DER
40.0819	-105.542	swamp, west of Red Rock Lake	Boulder	3,100	D.E. Ruiter	23-IX-1999	2m 2f	DER	DER
40.0819	-105.542	swamp, west of Red Rock Lake	Boulder	3,100	D.E. Ruiter	08-VIII-2003	1f	DER	DER, H 10, Z12
40.0819	-105.542	swamp, west of Red Rock Lake	Boulder	3,100	D.E. Ruiter	21-VII-2008	2m	DER	DER
40.081877	-105.541489	Red Rock Lake	Boulder	3,100	Unknown	09-VIII-1984	A	CSUC	DER, H 10, Z12
40.0819	-105.542	swamp, west of Red Rock Lake	Boulder	3,100	D.E. Ruiter	22-VIII-1996	8m 9f	DER	DER
40.0777	-105.58647	pond, W of Long L.	Boulder	3,210	D.E. Ruiter	22-VIII-1996	6m 3f	DER	DER
40.0777	-105.58647	pond, W of Long L.	Boulder	3,210	D.E. Ruiter	31-VII-2008	12m 9f	DER	DER
39.658306	-105.603522	Echo Lake	Clear Creek	3,235	D.E. Ruiter	30-VII-1998	1m	DER	DER, H 10, Z12
39.59502	-105.7112	just NW of Guanella Pass parking lots	Clear Creek	3,560	D.E. Ruiter	10-VIII-2002	1m 4f	DER	DER, H 10, Z12
39.79968	-105.79705	ponds at head of Hoop Creek upstream, from Hwy40	Clear Creek	3,660	Ruiter & Wuerthele	20-VIII-2009	14m 10f	DER	DER
40.149689	-105.691552	Bog, Stone Lake Trail	Grand	3,200	M. Al Mousa	17-VIII-2019	2m	CSUC	2019 - 2020
40.149689	-105.691552	Bog, Stone Lake Trail	Grand	3,200	M. Al Mousa	17-VIII-2019	11m 3f	CSUC	2019 - 2020

40.155628	-105.681526	Upper Lake	Grand	3,270	M. Al Mousa	17-VIII-2019	2m	CSUC	2019 - 2020
40.16564	-105.734199	Watanga Lake	Grand	3,285	M. Al Mousa	31-VIII-2019	26m 83f	CSUC	2019 - 2020
40.16564	-105.734199	Watanga Lake	Grand	3,285	M. Al Mousa	31-VIII-2019	53m 64f	CSUC	2019 - 2020
40.413	-105.824	Lake Irene Campground	Grand	3,250	Opler & Buckner	07-VIII-1992	2m	CSUC	DER
40.50941	-106.03418	Gould	Jackson	2,740	M.T. James	19-VIII-1940	1f	CSUC	DER, R95
40.56533	-105.58738	Pingree Park	Larimer	2,743	Beamer & Lawson	00-VIII-1924	6m	Snow Mus.	DER, R95, H10, Z12
40.56533	-105.58738	Pingree Park	Larimer	2,743	Anonymous	15-VIII-1934	2f	CSUC	DER, R95, H10, Z12
40.52045	-105.89388	Cameron Pass	Larimer	3,140	M.T. James	14-VIII-1946	2m	CSUC	DER, R95, H10, Z12
40.29241	-105.65702	The Loch	Larimer	3,115	B.C. Kondratieff	02-VIII-1988	13m 10f	CSUC	DER, R95, H10, Z12
40.29241	-105.65702	The Loch	Larimer	3,115	B.C. Kondratieff	24-VIII-1988	11m 15f	CSUC	DER, R95, H10, Z12
40.52045	-105.89388	Cameron Pass	Larimer	3,140	G.F. Knowlton	18-VIII-1940	1m 1f	INHS	DER, R95

40.52045	-105.89388	Cameron Pass	Larimer	3,140	G.F. Knowlton	21-VIII-1940	5m	INHS	DER, R95
40.52045	-105.89388	Cameron Pass	Larimer	3,140	H.H. Ross	18-VIII-1941	1m 8f	INHS	DER, R95
40.42089	-105.810408	Poudre Lakes	Larimer	3,271	M.T. James	24-VII-1938	1m	CSUC	DER, R95
40.602946	-105.683186	Browns Lake	Larimer	3,210	M. Al Mousa	07-VIII-2019	27m 5f	CSUC	2019 - 2020
40.54291	-105.66199	pond, Emmaline L. Trail	Larimer	3,355	M. Al Mousa	25-VIII-2019	2m 11f	CSUC	2019 - 2020
40.603386	-105.686374	Timberline Lake	Larimer	3,210	M. Al Mousa	07-VIII-2019	8m	CSUC	2019 - 2020
40.691754	-105.946088	Upper Sandbar Lake	Larimer	3,262	M. Al Mousa	13-VIII-2020	39m 15 f	CSUC	2019 - 2020
40.696375	-105.946991	Lower Sandbar Lake	Larimer	3,252	M. Al Mousa	13-VIII-2020	50m 49f	CSUC	2019 - 2020
40.696375	-105.946991	Lower Sandbar Lake	Larimer	3,252	M. Al Mousa	13-VIII-2020	3m 3f	CSUC	2019 - 2020
40.692683	-105.940984	Big Rainbow Lake	Larimer	3,270	M. Al Mousa	13-VIII-2020	2m	CSUC	2019 - 2020
40.69634	-105.952406	Rawah Lakes, L#1	Larimer	3,260	M. Al Mousa	13-VIII-2020	4m 2f	CSUC	2019 - 2020
40.69405	-105.945321	Camp Lake	Larimer	3,260	M. Al Mousa	13-VIII-2020	2m 6f	CSUC	2019 - 2020
40.557519	-105.815366	Trap Lake	Larimer	3,030	M. Al Mousa	13-VIII-2020	1m 1f	CSUC	2019 - 2020

40.556839	-105.789734	Peterson Lake	Larimer	2,896	M. Al Mousa	30-VII-2019	2m 2f	CSUC	2019 - 2020
40.61591	-105.84414	wetland near Laramie Lake	Larimer	2,835	B. Kondratieff & M. Al Mousa	24-VII-2019	5m 2f	CSUC	2019 - 2020
Limnephilus productus Banks, 1914									
40.20889	-105.83504	Shadow Mountain Dam, RMNP	Grand	2,545	P. Opler	29-VII-1995	1m	CSUC	DER
Limnephilus rhombicus (Linnaeus, 1758)									
40.38205	-106.62177	off County Road 15 (FR100), 0.25 Mi. off Hwy40	Grand	2,860	B. Kondratieff	07-VIII-2014	1f	CSUC	DER
Limnephilus sansoni Banks, 1918									
40.0777	-105.58647	pond, W of Long L.	Boulder	3,210	D.E. Ruiter	31-VII-1998	2p	DER	DER, H 10, Z12
40.30656	-105.84317	Green Mountain Employee Area	Grand	2,670	P. Opler	30-VIII-1997	3m 1f	CSUC	DER, R99
Limnephilus secludens Banks, 1914									
40.38963	-105.73494	Forest Lake	Larimer	3,140	C. & O. Flint	29-VII-1995	1m 1f	FLINT	DER
40.38963	-105.73494	Forest Lake	Larimer	3,140	D.E. Ruiter	29-VII-1995	1f	DER	DER
40.611854	-105.848707	Lost Lake	Larimer	2,835	Unknown	29-VII-1995	A	DER	DER, H 10, Z12
Limnephilus spinatus Banks, 1914									
40.50941	-106.03418	Gould	Jackson	2,740	H.M. Harris	28-VIII-1941	1f	INHS	DER
40.15483	-106.87337	Eagle Rock Lake	Routt	2,510	D.E. Ruiter	23-VIII-1991	1m 1f	DER	DER, R95
40.15483	-106.87337	Eagle Rock Lake	Routt	2,510	D.E. Ruiter	23-VIII-1991	2m	DER	DER, R95
Limnephilus sublunatus Provancher, 1877									
40.24469	-105.81318	Grand Lake	Grand	2,550	H.H. Ross	24-VII-1938	1m 1f	INHS	DER, R95

40.2844	-105.84533	Harbison Picnic Area	Grand	2,650	Opler & Buckner	13-VIII-1995	2m	CSUC	DER
40.2844	-105.84533	Harbison Picnic Area	Grand	2,650	Opler & Buckner	29-VII-1995	1f	CSUC	DER
40.56533	-105.58738	Pingree Park	Larimer	2,795	Beamer & Lawson	01-VIII-1924	1m 1f	Snow Mus.	DER, R95, H10, Z12
40.611854	-105.848707	Lost Lake, Rd103	Larimer	2,835	H. Malicky	29-VII-1995	1m 1f	Malicky	DER, H10
40.611854	-105.848707	Lost Lake, Rd103	Larimer	2,835	H. Malicky	29-VII-1995	A	INHS	DER, Z12
40.611854	-105.848707	Lost Lake, Rd103	Larimer	2,835	C. & O. Flint	29-VII-1995	4m 1f	FLINT	DER
40.73378	-105.90339	pond off Rawah Trail	Larimer	2,918	M. Al Mousa	13-VIII-2020	2f	CSUC	2019 - 2020
Limnephilus tarsalis (Banks, 1920)									
40.083518	-105.513119	near Ward	Boulder	2,870	Unknown	no date	1m	Malicky	DER, R95, H10, Z12
Limnephilus thorus Ross, 1938									
		Rocky Mountain National Park	Larimer		R.W. Fredrickson	23-VIII-1949	1m 1f	Snow Mus.	DER
Nemotaulius hostilis (Hagen, 1873)									
39.949625	-105.61661	Lost Lake, W. of Eldora	Boulder	2,985	Unknown	29-IX-1977	P	UCMC	H 2010, Z 2012
40.0777	-105.58647	west of Long Lake Trailhead, Ward	Boulder	3,210	D.E. Ruiter	13-VII-1998	1P	DER	DER, H 10, Z12
40.081877	-105.541489	Red Rock Lake, Ward	Boulder	3,100	Unknown	31-VII-1998	L	DER	DER, H10

40.081877	-105.541489	Red Rock Lake, Ward	Boulder	3,100	Unknown	09-IX-2006	L	CSUC	DER, H 10, Z12
40.30656	-105.84317	Green Mountain Employee Area	Grand	2,670	P. Opler	30-VIII-1997	1m	CSU	DER, Z12
40.31342	-105.64819	Bear Lake	Larimer	2,900	R.J. Muckenthal er	04-VIII-1994	1m	CSU	DER, H10
40.611854	-105.848707	Lost Lake, near FS Rd. 190	Larimer	2,835	D.E. Ruiter	29-VII-1995	3m 1f	DER, USNM	DER, H10
40.611854	-105.848707	Lost Lake, near FS Rd. 190	Larimer	2,835	C. & O. Flint	29-VII-1995	2m 2F	FLINT	DER
40.611854	-105.848707	Lost Lake, near FS Rd. 190	Larimer	2,835	Unknown	14-IX-2002	L	CSUC	DER, H10
Psychoglypha subborealis (Banks, 1924)									
40.081877	-105.541489	Red Rock Lake, Ward	Boulder	3,100	D.E. Ruiter	19-IX-1998		CSUC	DER, H10
40.20779	-105.56654	Wild Basin Trailhead, RMNP	Boulder	2,960		11-VI-1999		CSUC	DER, H 10, Z12
40.05094	-105.6057	Green Lake, L1	Boulder	3,430	Bushnell et al. 1987	Unknown			B87
40.04667	-105.60378	Albion Lake	Boulder	3,355	Bushnell et al	Unknown			B87
40.41888	-105.80603	1 Mi. E of Millner Pass	Larimer	3,400	Unknown	30-VII-1995		CSUC	DER
40.351902	-105.644585	Fern Lake Trailhead	Larimer	2,500	P. Opler	25-VI-1998		CSUC	DER, H 10, Z12
40.29241	-105.65702	above the Loch, RMNP	Larimer	3,115	Unknown	28-X-1998		CSUC	DER
40.36036	-105.60452	Moraine Park	Larimer	2,500	Unknown	31-V-1993		CSUC	DER, H 10, Z12
40.41379	-105.65795	Endo Valley Picnic Area	Larimer	2,627	Unknown	08-V-1994	A	CSUC	Z12

40.41379	-105.65795	Endo Valley Picnic Area	Larimer	2,627	Unknown	08-V-1994		CSUC	DER, H 10, Z12
40.37287	-105.61421	Upper Beaver Meadows Trailhead	Larimer	2,570	Unknown	21-IV-1990		DER	DER, H10
Psychoronia costalis Banks, 1901									
40.05094	-105.6057	Green Lake, L1	Boulder	3,430	Bushnell et al	Aknown			B87
40.05527	-105.62047	Green Lake, L4	Boulder	3,565	Bushnell et al	Aknown			B87
40.04667	-105.60378	Albion Lake	Boulder	3,355	Bushnell et al	Aknown			B87
40.052301	-105.630512	Green Lake, L5	Boulder	3,620	Bushnell et al	Aknown			B87
40.07785	-105.57514	Brainard Lake	Boulder	3,154	Unknown	31-VII-1998	A, P	DER	DER, H10
40.07785	-105.57514	Brainard Lake	Boulder	3,154	Unknown	29-VI-1986	p	DER	DER, H10
Molannidae									
Molanna flavicornis Banks, 1914									
39.860726	-105.413604	Golden Gate Canyon State Park	Boulder	2,510	D.J. Liewher	24-VI-1984	2 m	CSU	DER, H 10, Z12
40.077769	-105.586293	West of Long Lake	Boulder	3,210	D.E. Ruiter	29-VII-1994	14 L	DER	DER, H10
40.081877	-105.541489	Red Rock Lake, Ward	Boulder	3,100	D.E. Ruiter	29-VII-1994	1m	DER	DER
40.081877	-105.541489	Red Rock Lake, Ward	Boulder	3,100	D.E. Ruiter	29-VI-1986	14m 8f	DER	DER
40.081877	-105.541489	Red Rock Lake, Ward	Boulder	3,100	D.E. Ruiter	10-VII-1994	2m 1f	DER	DER
40.081877	-105.541489	Red Rock Lake, Ward	Boulder	3,100	D.E. Ruiter	22-VIII-1996	1L	DER	DER, H 10, Z12

40.0825	-105.5414	West of Long Lake Trailhead	Boulder	3,100	D.E. Ruiter	31-VII-1998	2m1f	DER	DER, H 10, Z12
40.081877	-105.541489	Red Rock Lake, Ward	Boulder	3,100	D.E. Ruiter	31-VII-1998	7m 1f	DER	DER, H 10, Z12
40.081877	-105.541489	Red Rock Lake, Ward	Boulder	3,100	D.E. Ruiter	13-VII-1982	11m 6f	DER	DER, H 10, Z12
40.012185	-105.581107	Rainbow Lakes, N. E. L.	Boulder	3,110	D.E. Ruiter	16-VII-1982	11m 4f	DER	DER, H 10, Z12
40.069053	-105.585555	Rainbow Lakes, upper Lake	Boulder	3,130	M. Al Mousa	23-VII-2019	1m 2f	CSU	2019 - 2020
40.081877	-105.541489	Red Rock Lake, W. of Ward	Boulder	3,100	Ruiter & Brooks	31-VII-2008	1m	DER	DER
40.081877	-105.541489	Red Rock Lake, W. of Ward	Boulder	3,100	M. Al Mousa	09-VII-2020	7m	DER	2019 - 2020
39.658306	-105.603522	Echo Lake	Clear Creek	3,240	D.E. Ruiter	30-VII-1998	1m 7f	DER	DER, H 10, Z12
39.658306	-105.603522	Echo Lake	Clear Creek	3,240	D. Leatherman	09-VII-2014	1m	CSU	DER
39.905892	-105.583332	Tolland, Sphagnum Bog	Gilpin	2,700	C.L. Remington	11-VII-1949	1f	IHNS	DER, H 10, Z12
39.88619	-105.5081	Snowline Lake	Gilpin	2,745	D.E. Ruiter	13-VII-1982	4m	DER	DER, Z12
40.386922	-106.587283	Muddy Pass Lake	Jackson	2,675	M. Al Mousa	18-VII-2020	1m 1f	CSUC	2019 - 2020
40.386922	-106.587283	Muddy Pass Lake	Jackson	2,675	M. Al Mousa	18-VII-2020	4m 16f	CSUC	2019 - 2020

40.386922	-106.587283	Muddy Pass Lake	Jackson	2,675	M. Al Mousa	18-VII-2020	40m 19	CSUC	2019 - 2020
40.326501	-105.625154	Bierstadt Lake, RMNP	Larimer	2,875	H. Rodeck	04-VII-1933	3m	CU-Museum	DER, H 10, Z12
40.611854	-105.848707	Lost Lake	Larimer	2,835	C.&O. Flint	29-VII-1995	1m	DER, FLINT	DER, H 10, Z12
40.611854	-105.848707	Lost Lake	Larimer	2,835	H. Malicky	29-VII-1995	8m 1f	Malicky	DER, H 10, Z12
40.611854	-105.848707	Lost Lake, near Cameron Pass	Larimer	2,835	D.E. Ruiter	13-VII-2011	22m 28f	DER	DER
40.617788	-105.839773	Laramie Lake	Larimer	2,846	B. Kondratieff &M. Al Mousa	24-VII-2019	1 m	CSU	2019 - 2020
40.557519	-105.815366	Trap Lake	Larimer	3,030	M. Al Mousa	30-VII-2019	3m 4f	CSU	2019 - 2020
40.556839	-105.789734	Peterson Lake	Larimer	2,900	M. Al Mousa	30-VII-2019	1m	CSU	2019 - 2020
40.611854	-105.848707	Lost Lake	Larimer	2,835	B. Kondratieff &M. Al Mousa	24-VII-2019	1m 1f	CSU	2019 - 2020
Phryganeidae									
Agrypnia deflata (Milne, 1931									
40.0775	-105.5861	pond, W of Long L.	Boulder	3,200	D.E. Ruiter	31-VII-1994	1f	DER	DER
40.0775	-105.5861	pond, W of Long L.	Boulder	3,200	D.E. Ruiter	31-VII-1998	6m 2f 1L	DER	DER, H 10, Z12
40.0775	-105.5861	pond, W of Long L.	Boulder	3,200	D.E. Ruiter	29-VII-1994	1f	DER	DER, H10

40.0775	-105.5861	pond, W of Long L.	Boulder	3,200	Ruiter & Brooks	31-VII-2008	1f	DER	DER
40.081877	-105.541489	Red Rock Lake, W. of Ward	Boulder	3,100	Unknown	07-VII-1984	L	ROME	H 10, Z 12
40.611854	-105.848707	Lost Lake, near FS Rd.190	Larimer	2,835	D.E. Ruiter	29-VII-1995	30m 1P	DER	DER, H 10, Z12
40.611854	-105.848707	Lost Lake, near FS Rd.190	Larimer	2,835	H. Malicky	29-VII-1995	5m	Malicky	DER, H 10, Z12
40.611854	-105.848707	Lost Lake, near FS Rd.190	Larimer	2,835	C. & O. Flint	29-VII-1995	30m 2f	FLINT	DER
Agrypnia glacialis Hagen, 1873									
40.557519	-105.815366	Trap Lake, FR 156	Larimer	3,030	D.E. Ruiter	21-VII-1999	1m	DER	DER, H 10, Z12
40.151977	-105.684858	Stone Lake	Grand	3,240	M. Al Mousa	17-VII-2019	9m 8f	CSU	2019 - 2020
Agrypnia straminea Hagen, 1873									
40.9336	-106.6114	Big Creek Lakes, Mt. Zirkel Wilderness	Jackson	2,765	R. Rader	25-VII-1996	1f	CSU	DER
40.8958	-106.6825	Seven Lakes	Jackson	3,275	B.P. Baldigo	03-VIII-1984	1m 1f	USEPA, LV	DER
40.310189	-105.651647	Nymph Lake, RMNP	Larimer	2,906	Unknown	26-VII-1983	A		DER, H 10, Z12
Phryganea cinerea Walker, 1852									
40.081877	-105.541489	Red Rock Lake, west of Ward	Boulder	3,100	D.E. Ruiter	10-VII-1994	1p	DER	DER, H 10, Z12
40.081877	-105.541489	Red Rock Lake, west of Ward	Boulder	3,100	D.E. Ruiter	29-VI-1986	6m 4p	DER	DER
40.081877	-105.541489	Red Rock Lake, west of Ward	Boulder	3,100	D.E. Ruiter	13-VII-1982	1m	DER	DER, H10

40.7808	-106.4931	Lake John, 14 miles NW of Walden	Jackson	2,565	D. Rees	26-VI-1994	1f	CSU	DER
40.611854	-105.848707	Lost Lake, near FS Rd.190	Larimer	2,835	C. & O. Flint	29-VII-1995	1m 1f	FLINT	DER, H 10, Z12
40.611854	-105.848707	Lost Lake, near FS Rd.190	Larimer	2,835	D. Rees	03-VII-2005	1m 1f	CSU	DER, H 10, Z12
40.611854	-105.848707	Lost Lake, near FS Rd.190	Larimer	2,835	D.E. Ruiter	13-VII-2011	1f	DER	DER
40.611854	-105.848707	Lost Lake, near FS Rd.190	Larimer	2,835	C. Utley	02-VII-2009	1f	CSU	DER
Polycentropodidae									
Polycentropus aureolus (Banks, 1930)									
40.2775	-105.8456	Harbison Picnic Area, RMNP	Grand	2,650	Opler & Buckner	29-VII-1995	1m	CSU	DER
40.611854	-105.848707	Lost Lake	Larimer	2,835	C. & O. Flint	29-VII-1995	1m	USNM	DER, H 10, Z12