Aquatic snails of the Bear and Powder River Basins, and Snowy Mountains of Wyoming

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Abstract
Freshwater snails are a diverse group of mollusks that live in a variety of aquatic ecosystems and many species are of conservation globally. About 37-39 species of aquatic snails likely live in Wyoming. The current study surveyed streams, wetlands, lakes and springs in the Bear and Powder River basins, and Snowy Mountains in Wyoming and identified 18 species. We measured basic water quality and habitat characteristics and at each site and within microhabitats. We found snails at 53% of sites we surveyed and they were usually most abundant in ecosystems with higher standing stocks of algae, substrate (e.g., wood or aquatic vegetation) and in habitats with slower water velocity (e.g., backwater and margins of streams). We discovered the Rocky Mountain Capshell (*Acroloxus coloradensis*) in the Snowy Mountains and we collected the Bear River endemic, Bear River Snail (*Pyrgulopsis pilsbryana*) in the Bear River basin. We updated an aquatic snail key for identifying species in Wyoming. The new observations provide information in basins that have not been previously surveyed for snails and can be used to make informed management decisions.

Introduction
About 99% of animal species are invertebrates (Ponder and Lunney 1999), yet far less is known about these animals compared to their vertebrate counterparts. Invertebrates are composed of multiple phyla such as Arthropoda (insects, spiders and crustaceans), Cnidaria (jellyfish), Nematomorpha (horsehair worms) and Molluska (snails and bivalves). Molluska are most diverse in marine ecosystems, but freshwater mollusks can be abundant in freshwater ecosystems and are often critical members of the community (e.g., Vaughn and Hakenkamp 2001, Limm and Powers 2011). Additionally, freshwater mollusks, both bivalves (e.g., mussels and clams) and gastropods (e.g., snails and limpets), are declining worldwide (Lydeard et al. 2004). About 7000 species of freshwater mollusks have been described and taxonomists estimate that another 7000 species may be undescribed (Lydeard et al. 2004). Freshwater mollusks are listed as the animal group in most need of conservation because of their declines. For example, 10% of the described species of freshwater mollusks were listed on the ICUN Red list and 37.5% of recorded animal extinctions have been gastropods.

Knowledge of freshwater mollusks in Wyoming has grown in recent years, but we still lack basic information about their status and distribution. Beetle (1989) published a critical paper listing the mollusks collected in Wyoming granting us the first knowledge of what species occur here, but the information was typically at the county- or state-level. Subsequent work focused on river basins giving us a closer look at where these species occur. The Wyoming Game and Fish Department devoted resources to surveying mussels (Mathias 2014a, 2014b, 2015a, 2015b, Tronstad and Mathias 2015, Wilmot et al. 2017, 2019, Tronstad et al. 2020) and snails in the state. Snails have been surveyed in the North Platte, Bighorn (Narr 2011), Green and Snake River Basins in Wyoming (Tronstad and Andersen 2018). Our currently study surveyed aquatic snails in the Bear and Powder River basins, and Snowy Mountains of Wyoming to expand our knowledge of these mollusks in Wyoming. Our goal was to describe the abundance, distribution and habitat associations of aquatic snails. Our specific goals were to: 1.) Survey a variety of habitats for aquatic snails and 2.) Collect habitat information to learn about where each species lives. Several aquatic snails are of management concern, and understanding their distribution and status in the state will help manage these mollusks. Our surveys also provide baseline information about these little known invertebrates.

Study Area
We collected snails in aquatic ecosystems in the Bear and Powder River basins, and Snowy Mountains of Wyoming. The Bear River is a closed river basin that flows into the Great Salt Lake (19,631 km^2; Shiozawa and Rader 2005). The headwaters of the Bear River are in the Unita Mountains where the river flows north winding in and out of Wyoming and Utah until it flows into Idaho north of Cokeville, Wyoming and then south again in into Utah. Annual precipitation in the basin averages 56 cm and the river flows through temperate mountain forest and desert biomes. Land use is dominated by agriculture, recreation and grazing (Shiozawa and Rader 2005). The Bear River basin is primarily composed of sedimentary bedrock.

The Powder River is part of the Yellowstone River basin that flows into the Missouri River in western North Dakota. The Yellowstone River basin has an area of 182,336 km^2 (Galat et al. 2005) and the Powder River basin consists of 28% of that area (50,505 km^2; Luppens et al. 2013). Much of the Powder River originates in the Bighorn Mountains and flows north into Montana and into the Yellowstone River near Mile City, Montana. Annual precipitation in the Yellowstone River basin averaged 29.5 cm and the river flows through temperate mountain forest and temperate grasslands. Land use is dominated by range, forest, agriculture and mining. The geology of the Bighorn mountains is igneous, metamorphic and sedimentary bedrock, and the basin is sedimentary. Several major tributaries flow into the Powder River in Wyoming, including the South, Middle and North Forks of the Powder River, Crazy Woman Creek and the Red Fork of the Powder River.

The Snowy Mountains are in the North Platte River basin and with the highest elevation being 3663 m at Medicine Bow Peak. The area is forested by conifer species such as lodge pole pine (*Pinus contorta*) and subalpine fir (*Abies lasiocarpa*). A variety of streams, wetlands, springs and lakes cover the mountains and the landscape was carved by glaciers. The geology consists of igneous, metamorphic and sedimentary bedrock. Up to 152 cm of precipitation falls in the Snowy Mountains annually.

Methods
We sampled snails in a variety of aquatic habitats (ponds, lakes, streams, rivers, springs, and wetlands) in the Bear and Powder River basins, and Snowy Mountains of Wyoming. Snails were preserved in ~80% ethanol and identified in the laboratory using a key developed by Rob Dillon and Lusha Tronstad for Wyoming (Tronstad and Andersen 2018) and we updated the key (Appendix 1). Through data collections in the literature, museums and reports, we found records for 55 species of aquatic snails in Wyoming. Rob Dillon, snail expert for North America, refined the list to 37-39 species in Wyoming based on his knowledge of snail taxonomy. Several species were lumped together and the synonymies are listed in Appendix 2.

We sampled each basin to deliberately collect a high diversity of snail taxa. Using GIS, we stratified each basin into watersheds (HUC 10) and five aquatic habitat types (large streams, small streams, palustrine, lacustrine and springs). Stream Strahler order was estimated based on the National Hydrography dataset. Small streams were stream order 1 or 2. Large streams were lotic ecosystem with a stream order of 3 or higher. Lentic ecosystems were divided into palustrine (wetland) and lacustrine (lake) using the National Wetlands Inventory dataset. Palustrine ecosystems are wetlands that are <8 ha in surface area and >30% vegetated cover. Lacustrine ecosystems are lakes that are >8 ha in surface area and < 30% vegetated cover. We sampled springs whenever we encountered them. We randomly selected four locations of each type in each HUC 10 watershed using GIS or those that were accessible and had water. Typically one type of each aquatic ecosystem was visited in as many HUC10 watersheds as possible depending on conditions and access. Additionally, we selected sites in each basin to deliberately target particular taxa of conservation concern (i.e., species of greatest conservation need; SGCN). We captured snails using a variety of techniques depending on the ecosystem and the most commonly used methods were dip nets and hand collecting. We searched in different microhabitats by completing one to five 10 minute surveys at each site (n = 4). These collections estimated abundance of snails in each microhabitat (catch per unit effort of time; CPUE).

We recorded site conditions to describe areas where snails were living. We recorded characters at both the site level and within each microhabitat searched. At the site level, we recorded the type of ecosystem we sampled (i.e., large or small stream, wetland, lake or spring). We collected basic water quality (water temperature, dissolved oxygen, specific conductivity, pH and oxidation-reduction potential) using a Yellow Springs Instrument Professional Plus where dissolved oxygen (DO) was calibrated daily, and specific conductivity (SPC), pH and oxidation-reduction potential (ORP) were calibrated at least every 4 days. We measure ecosystem width in two places and riparian height using a range finder. We recorded several characteristics of each microhabitats we sampled during each 10 minute surveys. In streams, we categorized microhabitats as main channel (usually riffles and runs), pools, stream margin, side channel and backwater habitats. In lakes and wetlands, we categorized microhabitats as aquatic vegetation (submerged and emergent vegetation, rushes, willows, or other plants growing out of the water), fine sediment, wood or rock. Springs were categorized as either standing or flowing water. We documented the type of substrate snails were collected on as fine substrate (clay, sand or silt), gravel, cobble, boulder or wood. The type of vegetation was noted as submerged aquatic vegetation (SAV), emergent aquatic vegetation (EAV), algae (lacking vascular plants) or none (plants and algae not visible). We ranked the standing stock of algae from 1 (little visible algae) to 3 (very green). We recorded habitat features at each site, regardless of capture success.

We preserved captured snails, identified them in the laboratory and analyzed the data. Snails with opercula were relaxed in water with methanol crystals before preserving in ethanol to aid identification by relaxing their foot. Samples were taken back to the laboratory where we identified specimens under dissecting and compound microscopes. We calculated an estimate of abundance (CPUE) based on the number of snails we collected divided by the time searched (snails/minute). Analyses and plots were done in R (R core development Team, 2017) using the plyr package (Wickham 2011) and ggplot (Wiclham et al. 2016). We analyzed how the CPUE of snails differed among ecosystem characteristics using generalized linear models and estimated differences among categorial variables using estimated marginal means (emmeans; Length 2021)

Results

We collected 4871 live snails and 498 snail shells (non-living) at 33 sites in the Bear River Basin, 77 sites in the Powder River Basin and 40 sites in the Snowy Mountains (150 sites total). Snails lived at 53% of the sites we visited; we found snails at 49% of sites we surveyed in the Bear River basin, 58% of sites in the Powder River Basin and 48% of sites in the Snowy Mountains. We collected 18 species of aquatic snails with 15 species occurring in the Bear River basin and the Snowy Mountains, and 10 species identified in the Powder River basin. Physidae were the most abundant family of snails collected in our surveys (61% of live individuals), followed by Lymnaeidae (15%), Planorbidae (9%) Tateidae (7%), Ancylidae (3%), Vavatidae (2%), Hydrobiidae (2%) and Acroloxidae (<1%). The family Thiaridae (6.7 live snails/min) had the highest mean CPUE followed by Hydrobiidae (2.0 snails/min), Physidae (1.8 snails/min), Valvatidae (0.94 snails/min), Lymnaeidae (0.90 snails/min), Ancylidae (0.65 snails/min) and Acroloxidae (0.20 snails/min). *Physa* (61% of individuals) and *Lymnaea* (15%) were the most common genera of snails collected followed by *Gyraulus* (7.5%), *Potamopyrgus* (7.1%), *Ferrissia* (3.0%), *Valvata*

(2.1%), *Helisoma* (1.7%), *Pyrgulopsis* (1.3%), *Colligyrus* (0.66%), *Promenentus* (0.51%), *Aplexa* (0.04%) and *Acroloxus* (0.04%).

The frequency at which we collected taxa differed among species. The species *Potamopyrgus antipodarum* (6.7 snails/min) had a high CPUE where they were found and we collected them at 2 sites in a single stream followed by *Colligyrus greggi* (3.3 snails/min), *Physa gyrina* (1.8 snails/min), *Physa acuta* (1.7 snails/min), *Pyrgulopsis pilsbryana* (1.5 snails/min), *Lymnaea catascopium* (1.3 snails/min), *Lymnaea bulimoides* (1.1 snails/min), *Valvata sincera* (0.93 snails/min), *Gyraulus parvus* (0.74 snails/min) and *Lymnaea humilis* (0.51 snails/min). *Aplexa hypnorum* (<0.01 snails/min), *Gyraulus circumstriatus* (0.05 snails/min), *Lymnaea elodes* (0.1 snails/min), *Acroloxus coloradensis* (0.2 snails/min), *Promenetus exacuous* (0.33 snails/min) and *Lymnaea columella* (0.43 snails/min) had the lowest mean catch per unit effort where we collected them.

Table 2. The number live, shells (not living) and total number of individuals collected for each snail species by family. Non-native species are marked with an asterisk.

Species	Family	Live	Shell	Total
Acroloxus coloradensis	Acroloxidae	2	0	2
Ferrissia fragilis	Ancylidae	116	0	116
Colligyrus greggi	Hydrobiidae	33	0	33
Pyrgulopsis pilsbryana	Hydrobiidae	24	1	25
Lymnaea bulimoides	Lymnaeidae	363	22	385
Lymnaea catascopium	Lymnaeidae	193	22	215
Lymnaea columella	Lymnaeidae	24	0	24
Lymnaea elodes	Lymnaeidae	4	10	14
Lymnaea humilis	Lymnaeidae	120	6	126
Aplexa hypnorum	Physidae	0	1	1
Physa acuta	Physidae	227	2	229
Physa gyrina	Physidae	2842	167	3009
Gyraulus circumstriatus	Planorbidae	1	0	1
Gyraulus parvus	Planorbidae	344	134	478
Helisoma trivolvis	Planorbidae	67	94	161
Promenetus exacuous	Planorbidae	26	2	28
*Potamopyrgus antipodarum**	Tateidae	576	0	576
Valvata sincera	Valvatidae	106	8	114

Catch per unit effort of snails varied among some of the parameters measured (Table 1). Snail CPUE was higher at lower specific conductivity (Figure 1a), higher percent saturation of dissolved oxygen (Figure 1b), higher pH (Figure 1c) and higher standing stock of algae (biofilm rank; Figure 1d). Overall, we captured more snails in stream and wetland ecosystem types (Figure 1d). Within microhabitats at a site, we captured more snail in slower moving water (Figure 2a), on algae, submerged aquatic vegetation (Figure 2b) and on wood (Figure 2c), and in shallower water (Figure 2d). The CPUE for snails did not vary among microhabiats in streams and springs, but we captured more snails in the open water and marginal habitats of wetlands (Figure 2e).

Table 2. The number of live snails collected varied with some variables. Relationships were calculated using generalized linear models and we report the t-value, p-value and differences. Estimated marginal means were calculated to estimate differences among categorical variables and slopes measured the relationship with continuous variables.

Variable	t-value	p-value	Differences
Microhabitats within aquatic ecosystem types			
Lentic	-0.09 to 1.7	0.10 to 0.93	More snails in open water (p <0.06), and along margins than on sediments (p = 0.04)
Springs	0.97	0.36	No difference
Streams	-0.90 to 1.3	0.2 to 0.97	No differences
Characteristics within microhabitats among all ecosystem types			
Dominant substrate	0.10 to 0.39	0.70 to 0.93	No differences
Vegetation	-2.9 to 10.1	<0.001 to 0.65	Microhabitats with no visible vegetation had fewer snails than areas with submerged aquatic vegetation and algae
Water depth	-2.3	0.03	No relationship
Water velocity	0.41 to 1.8	0.07 to 0.68	More snails collected in slow than medium velocity water (p = 0.11)
Water quality at the site level			
Dissolved oxygen (% saturation)	2.4	0.02	Higher percent saturation of dissolved oxygen meant higher CPUE of snails
Dissolved oxygen (mg/L)	1.2	0.24	No relationship
ORP	0.008	0.99	No relationship
pH	2.5	0.01	Most snails collected at pH >7
Specific conductivity	2.0	0.05	More snails at higher specific conductivity
Temperature	-0.27	0.79	No relationship
Characteristics of the ecosystem at the site level			
Biomass Rank	-2.8 to 6.6	<0.07	Fewer snails at sites with little biofilm vs. green sites (p = 0.11)
Ecosystem type	0.70 to 2.4	0.01 to 0.48	Lakes had fewer snails than large streams (p = 0.05)
Elevation	-0.32	0.75	No relationship
Fish presence	0.48 to 3.3	<0.001 to 0.63	No difference
Riparian height	-0.52	0.60	No relationship
Width	-0.77	0.44	No relationship

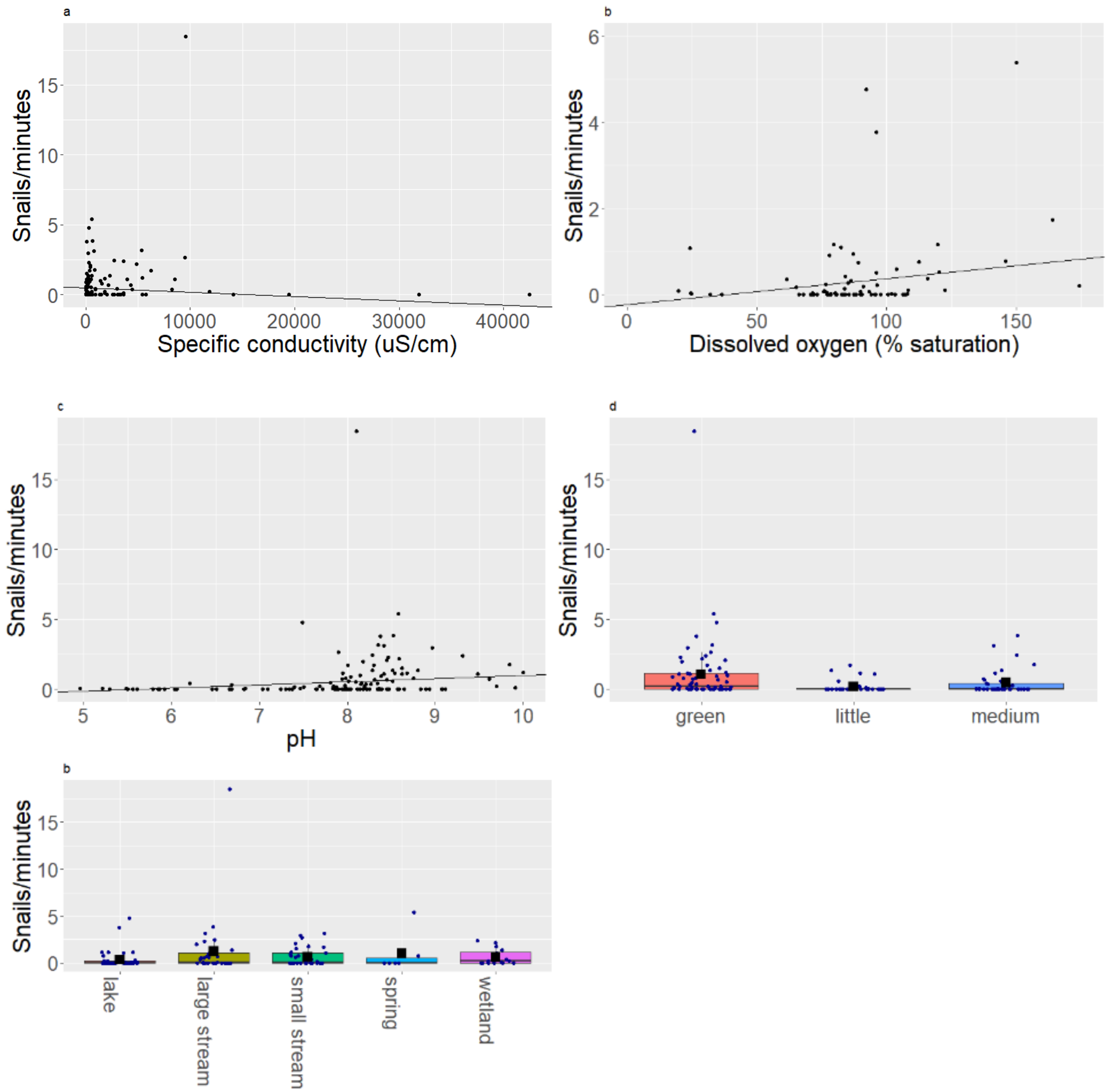


Figure 1. Mean catch per unit effort (snails/minute) of snails differed by a) specific conductivity, b) the percent saturation of dissolved oxygen and c) pH, d) biofilm rank and e) ecosystem type. For boxplots, black squares are means, bold lines are medians, lower and upper extends of the box are the 25th and 75th percentiles, whiskers are the minimum and maximum values excluding outliers and blue circles are all the data points. Scatterplots show all the collected points and the relationship between the variables.

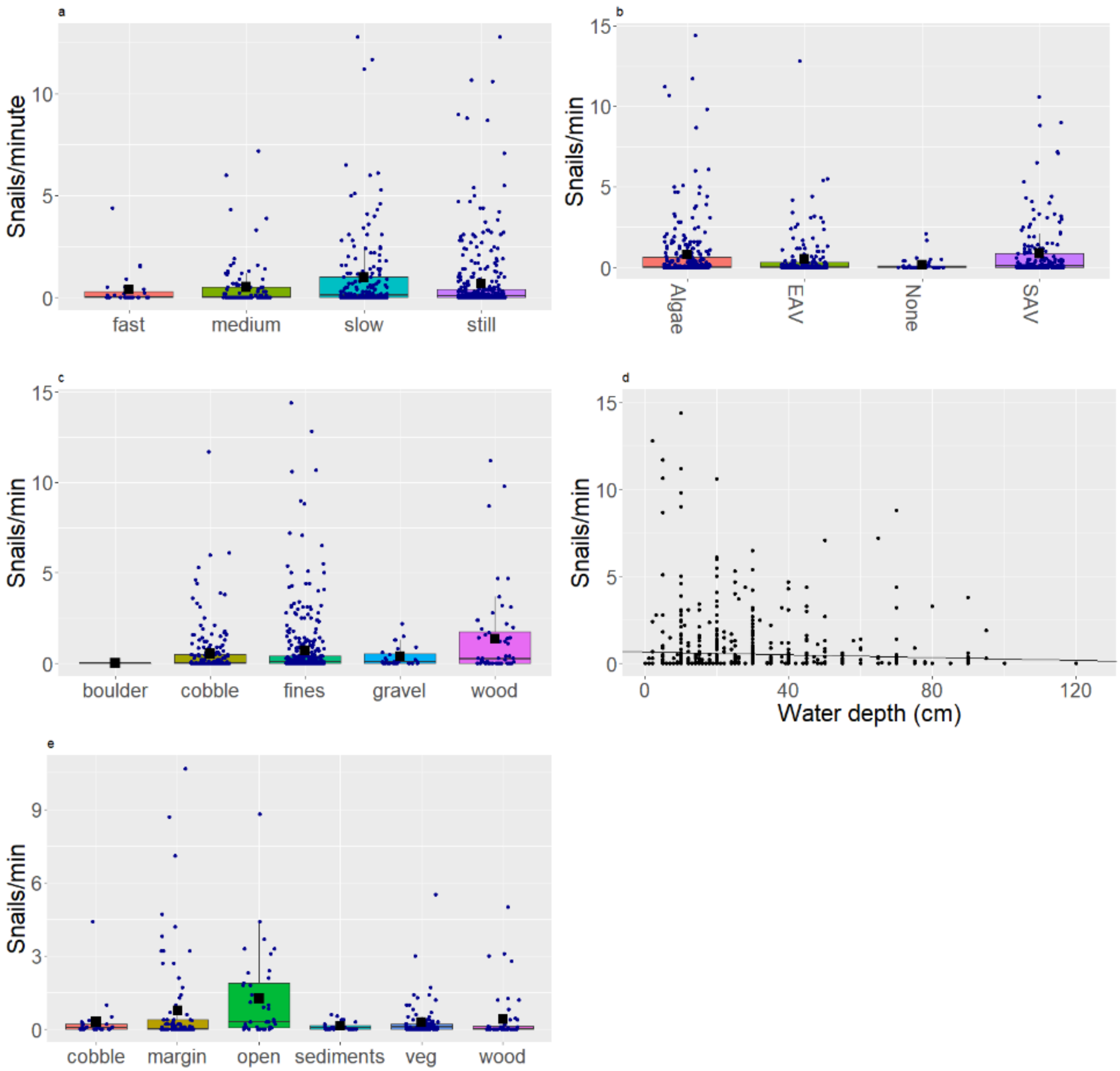
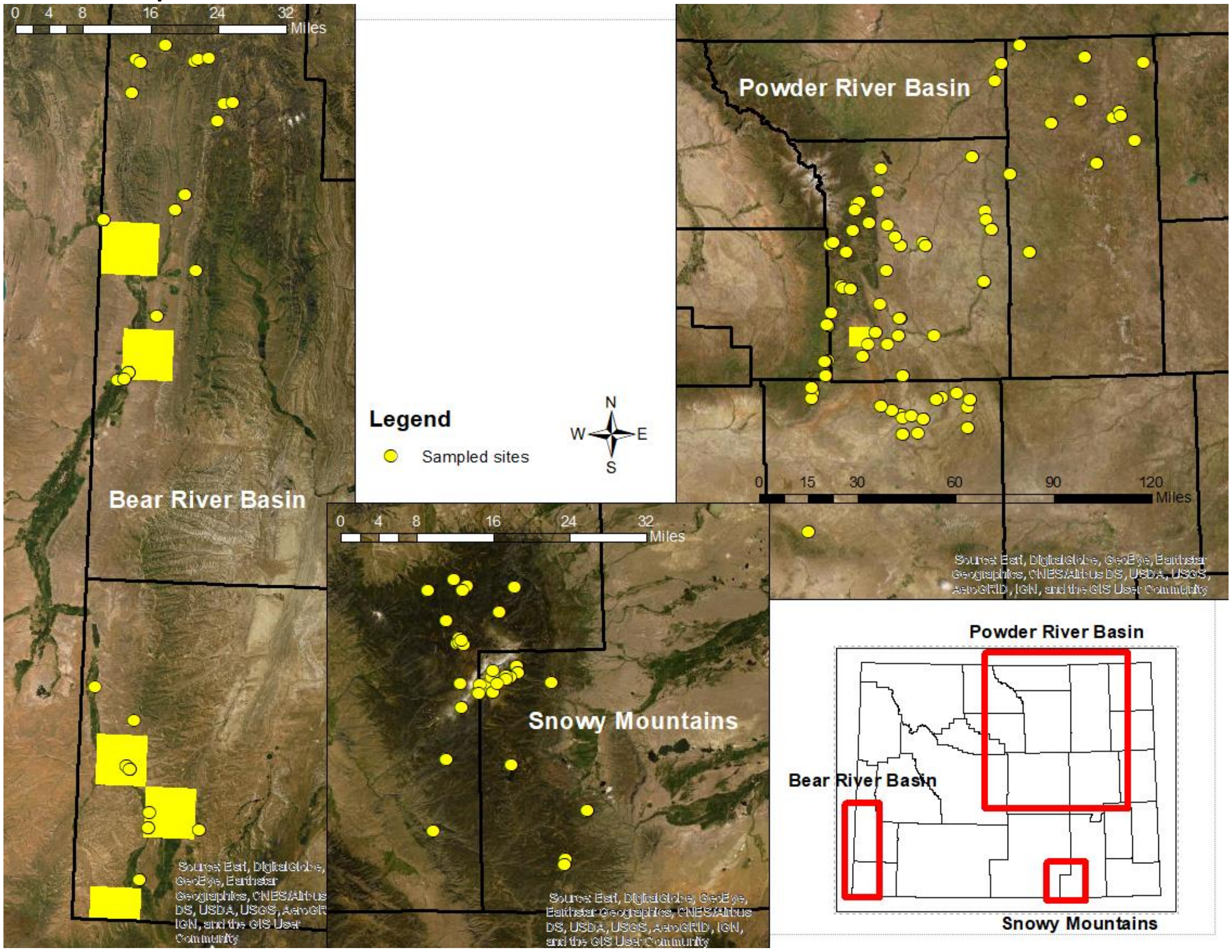


Figure 2. The catch per unit effort of snails (snails/min) varied within microhabitats by a) water velocity, b) vegetation (submerged aquatic vegetation = SAV, emergent aquatic vegetation = EAV), c) dominant substrate, d) water depth and e) habitat sampled in lentic habitats. For boxplots, black squares are means, bold lines are medians, lower and upper extends of the box are the 25th and 75th percentiles, whiskers are the minimum and maximum values excluding outliers and blue circles are all the data points. Scatterplots show all the collected points and the relationship between the variables.

The following pages provide species-specific information. The *All Sites Sampled* account provides a map of all the sampled locations as well as all the categories of habitat characteristics. We provide the mean and range in water quality measurements for all ecosystems sampled. If the species was collected at a single location, the range of values were not reported.

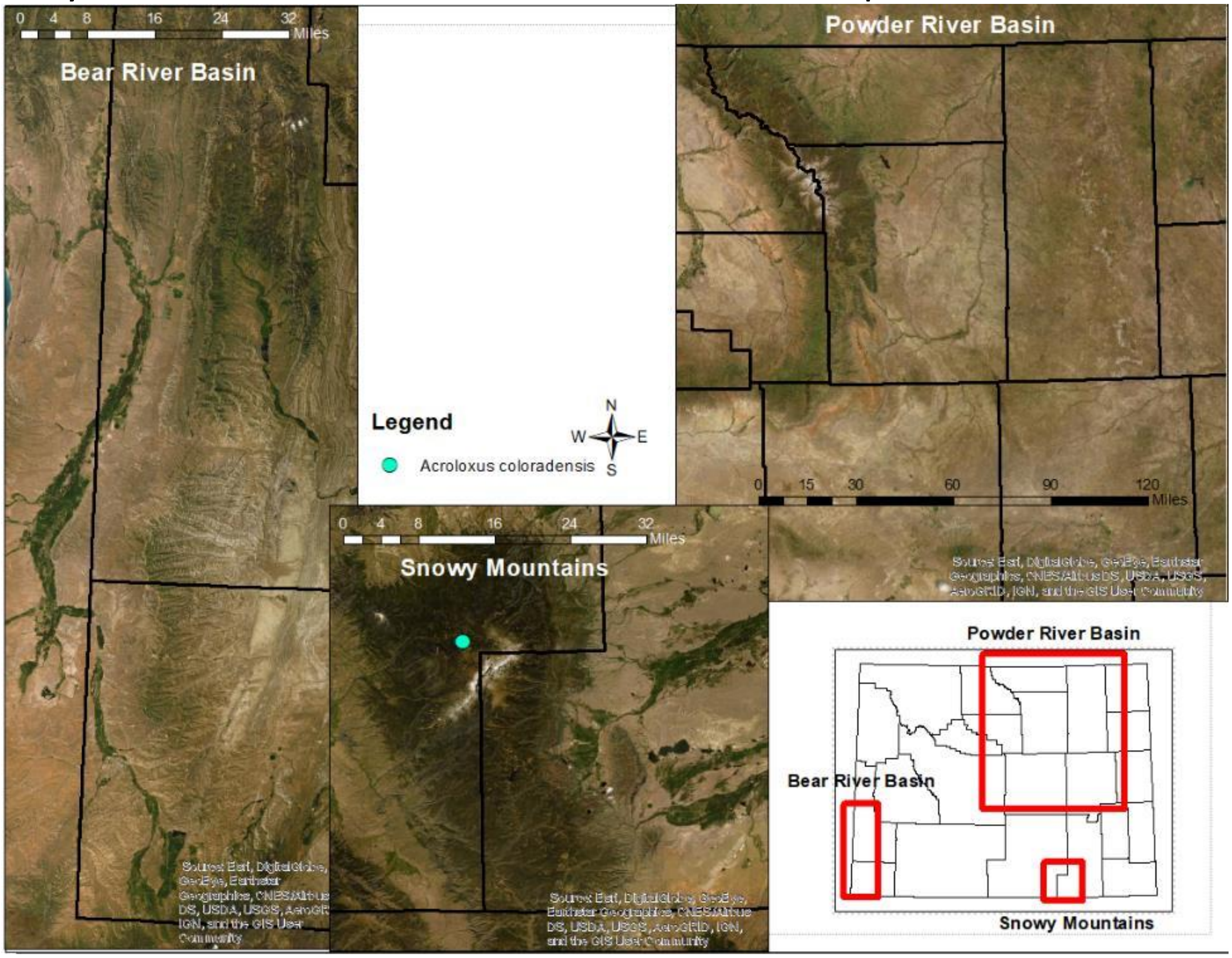
Account description
Basins: What basins the species was collected in
Number of sites: Number of sites the species was collected at
Aquatic ecosystem type: Type of aquatic ecosystem the species was collected in
Substrate: Type of substrate we collected the species on
Vegetation: Type of vegetation the species was collected on
Habitat: Microhabitat type the snail was collected in
Streams: main channel, side channel, backwater, pool and margin
Wetlands and *lakes*: rock, wood, aquatic vegetation and fine sediment
Springs: standing or flowing
Ecosystem width: Width of the stream, river, wetland, lake or spring
Size range collected: The smallest and largest shell length of the species collected
CPUE: Catch per unit effort of the species (snails/min; mean and range)
Water temperature: Water temperature (°C; mean and range)
% DO: Percent saturation of dissolved oxygen (mean and range)
DO: Dissolved oxygen (mg O_2/L; mean and range)
Specific conductivity: Concentration of dissolved salts in the water (µS/cm; mean and range)
pH: pH of the water (mean and range)
Oxidation-reduction potential: Correlated with oxygen concentration and groundwater fluxes. Indicates the types of reactions occurring in an ecosystem (mV; mean and range)
Note: Comments or observations about the species in Wyoming.

All Sites Sampled



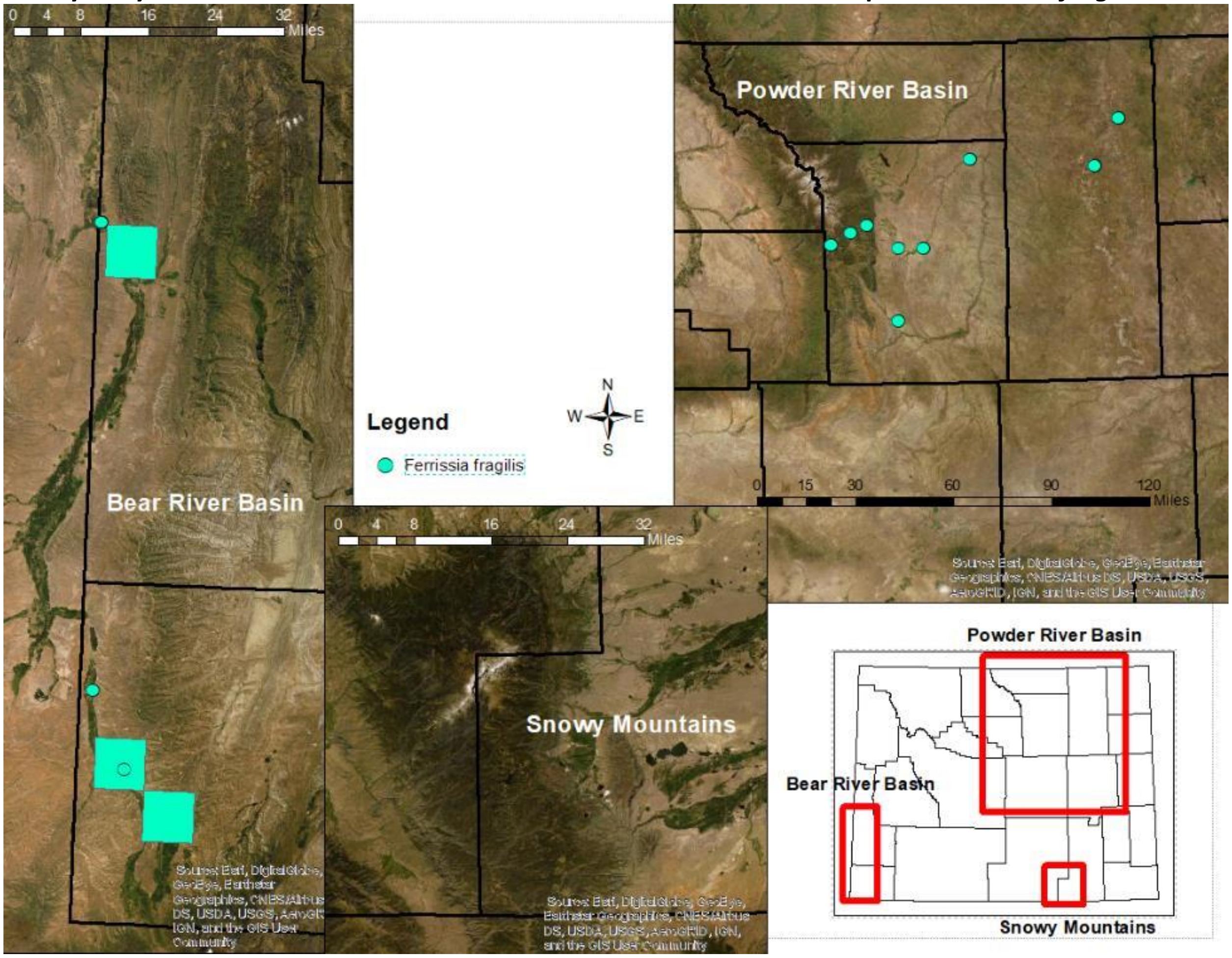
Basins: Bear and Powder River basins, Snowy Mountains
Number of sites: 150
Aquatic ecosystem type: Large and small streams, lakes, wetlands and springs
Substrate: Fine sediment, gravel, cobble and wood
Vegetation: Submerged and emergent aquatic vegetation, algae and non (no visible algae or plants)
Habitat: Streams (main channel, side channel, backwater, pool and margin), wetlands and lakes (rock, wood, aquatic vegetation, and fine sediments), and springs (standing or flowing)
Ecosystem width: 81.6 m (0.4-539)
Size range collected: 0.75-27 mm length
CPUE: 0.70 snails/min (0-14.4)
Water temperature: 16.1°C (5.2-29.5)
% DO: 87.2% (19.7-174.2)
DO: 9.2 mg O_2/L (1.6-28)
Specific conductivity: 2157 µS/cm (5-42,506)
pH: 7.9 (5.0-10)
Oxidation-reduction potential: 31.5 mV (-101-219)
Notes: Anything of interest about the snail.

Family: Acroloxidae **Species: *Acroloxus coloradensis***

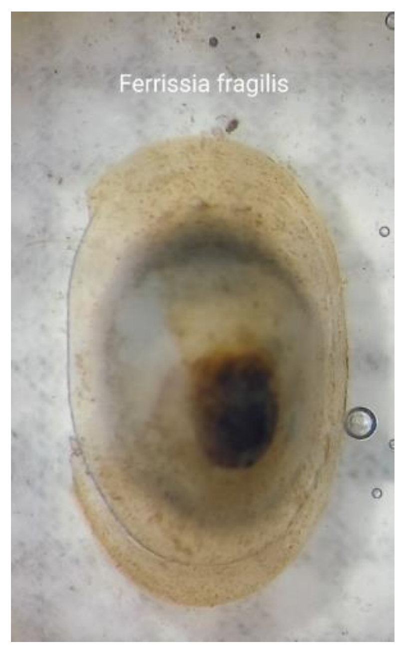


Basins: Snowy Mountains
Number of sites: 1
Aquatic ecosystem type: Lake
Substrate: Fine sediment
Vegetation: Emergent aquatic vegetation
Habitat: Cobble
Ecosystem width: 143 m
Size range collected: 3.75-4.0 mm length
CPUE: 0.2 snails/min
Water temperature: 22.2
% DO: 75.9%
DO: 6.7 mg O_2/L
Specific conductivity: 17.3 µS/cm
pH: 5.0
Oxidation-reduction potential: 91.6 mV
Notes: Previously known from 1 lake in Montana, 6 lakes in Colorado and isolated populations in Canada.

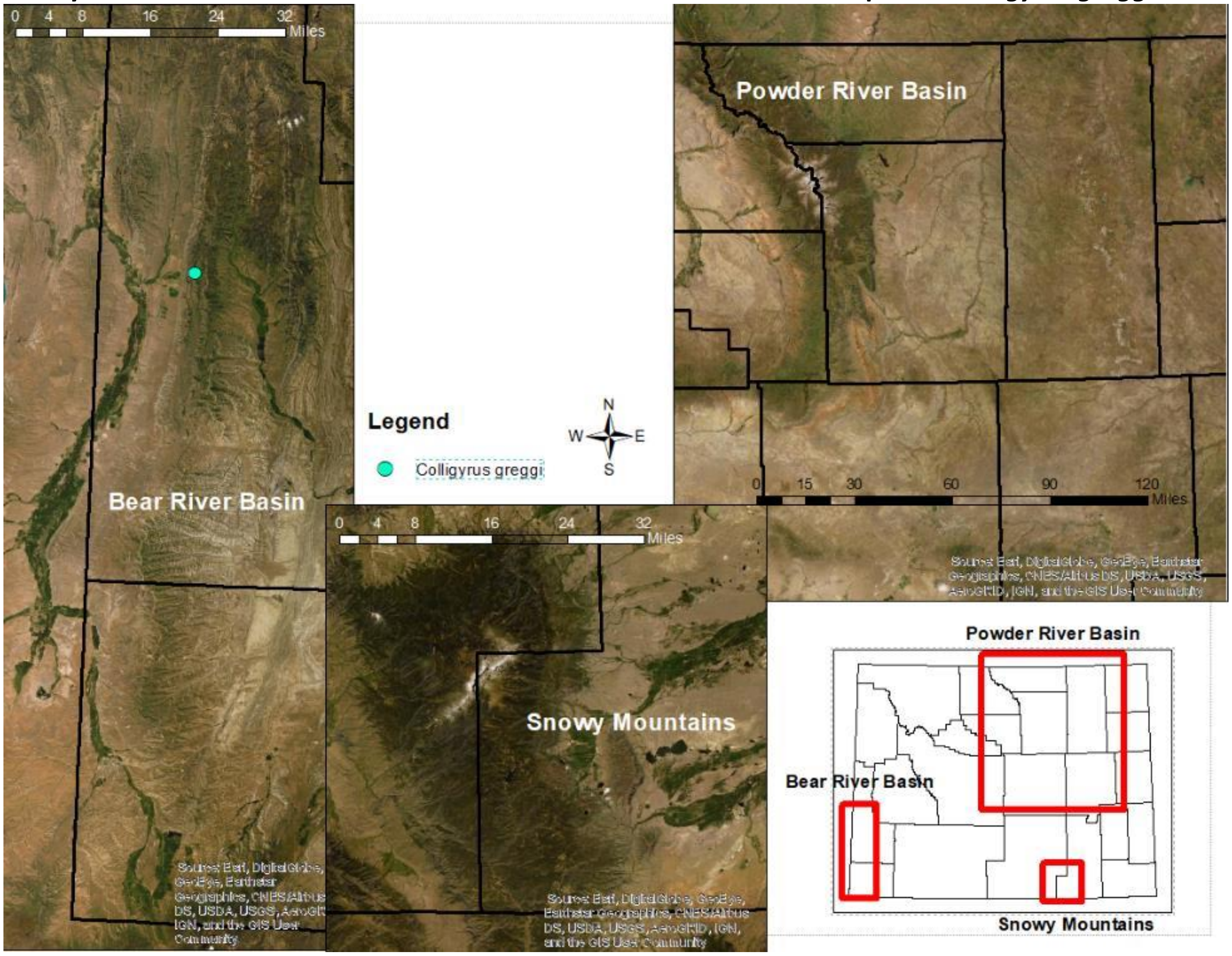
Family Ancylidae **Species:** ***Ferrissia fragilis***



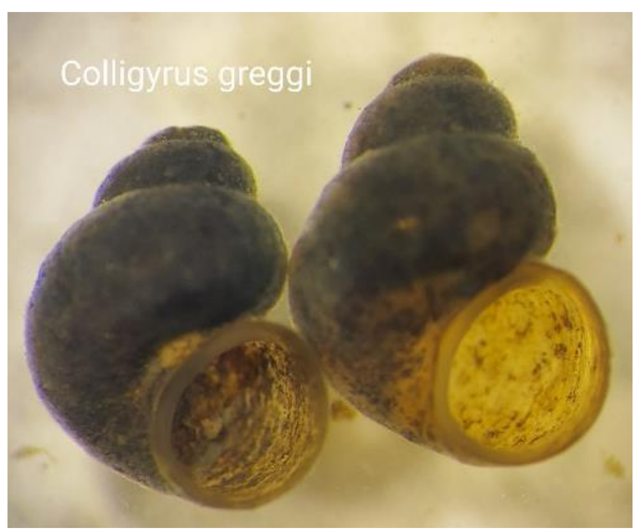
Basins: Bear and Powder
Number of sites: 7
Aquatic ecosystem type: Large and small streams
Substrate: Fine sediment, gravel, cobble and wood
Vegetation: Algae, emergent and submergent aquatic vegetation
Habitat: Main channel and margin of streams
Ecosystem width: 8.4 m (0.4-22.8)
Size range collected: 2-6 mm length
CPUE: 0.65 snails/min (0.1-2.2)
Water temperature: 13.6°C (8.1-18.6)
% DO: 68.7% (24-120)
DO: 9.5 mg O_2/L (8.7-11.2)
Specific conductivity: 1630 µS/cm (39-4282)
pH: 8.2 (7.8-8.5)
Oxidation-reduction potential: 51.2 mV (-5.7-190.5)
Notes: This snail is a limpet and attaches to solid objects (e.g., rocks, leaves, etc).



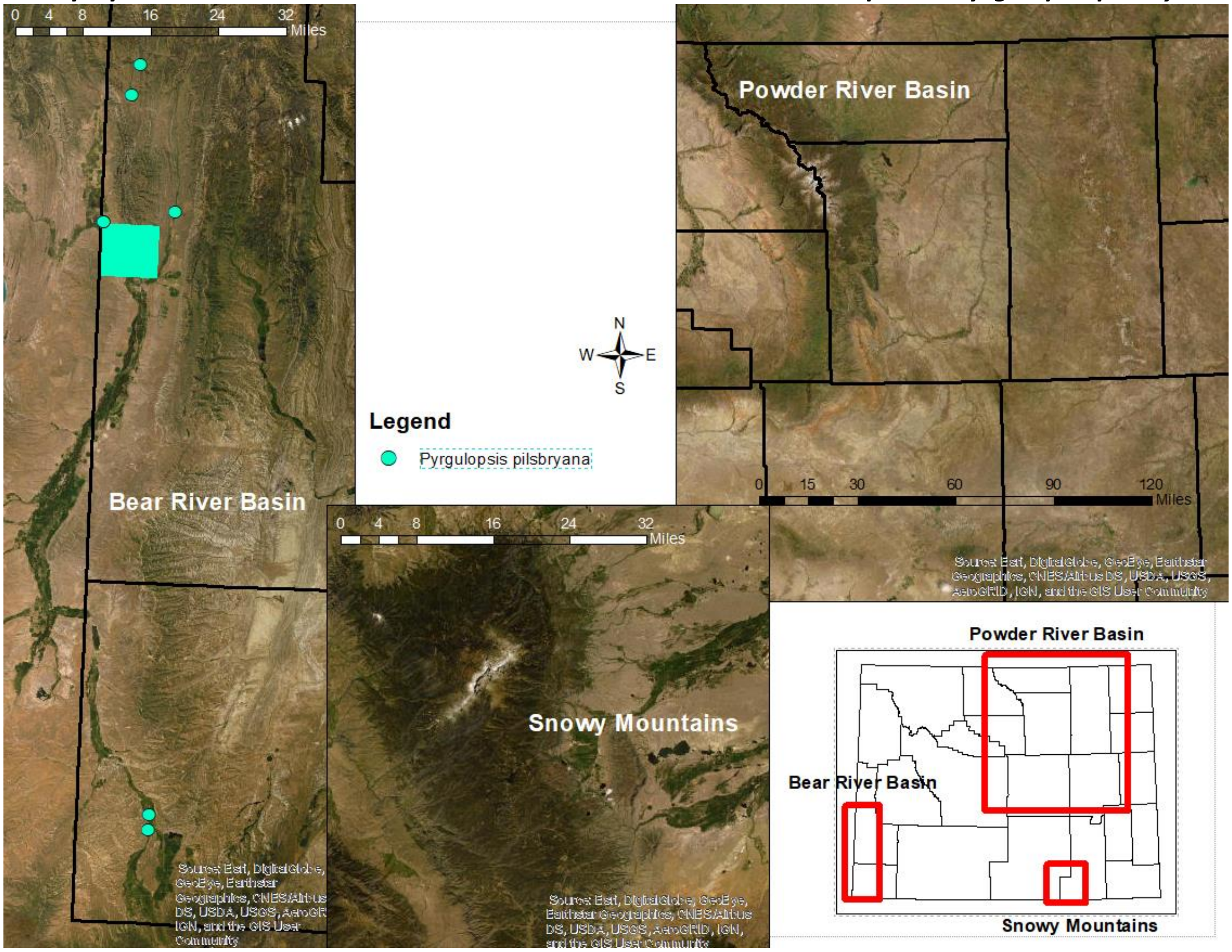
Family Amnicolidae **Species: *Colligyrus greggi***



Basins: Bear
Number of sites: 1
Aquatic ecosystem type: Small stream
Substrate: Cobble
Vegetation: Algae
Habitat: Main channel
Ecosystem width: 0.5 m
Size range collected: 1.5-3 mm length
CPUE: 3.3 snails/min
Water temperature: 7.4°C
DO: 9.8 mg O_2/L
Specific conductivity: 395 µS/cm
pH: 8
Oxidation-reduction potential: 209 mV
Notes: *Colligyrus greggi* is an operculate snail (has gills) that was previously only known from the Snake River basin.

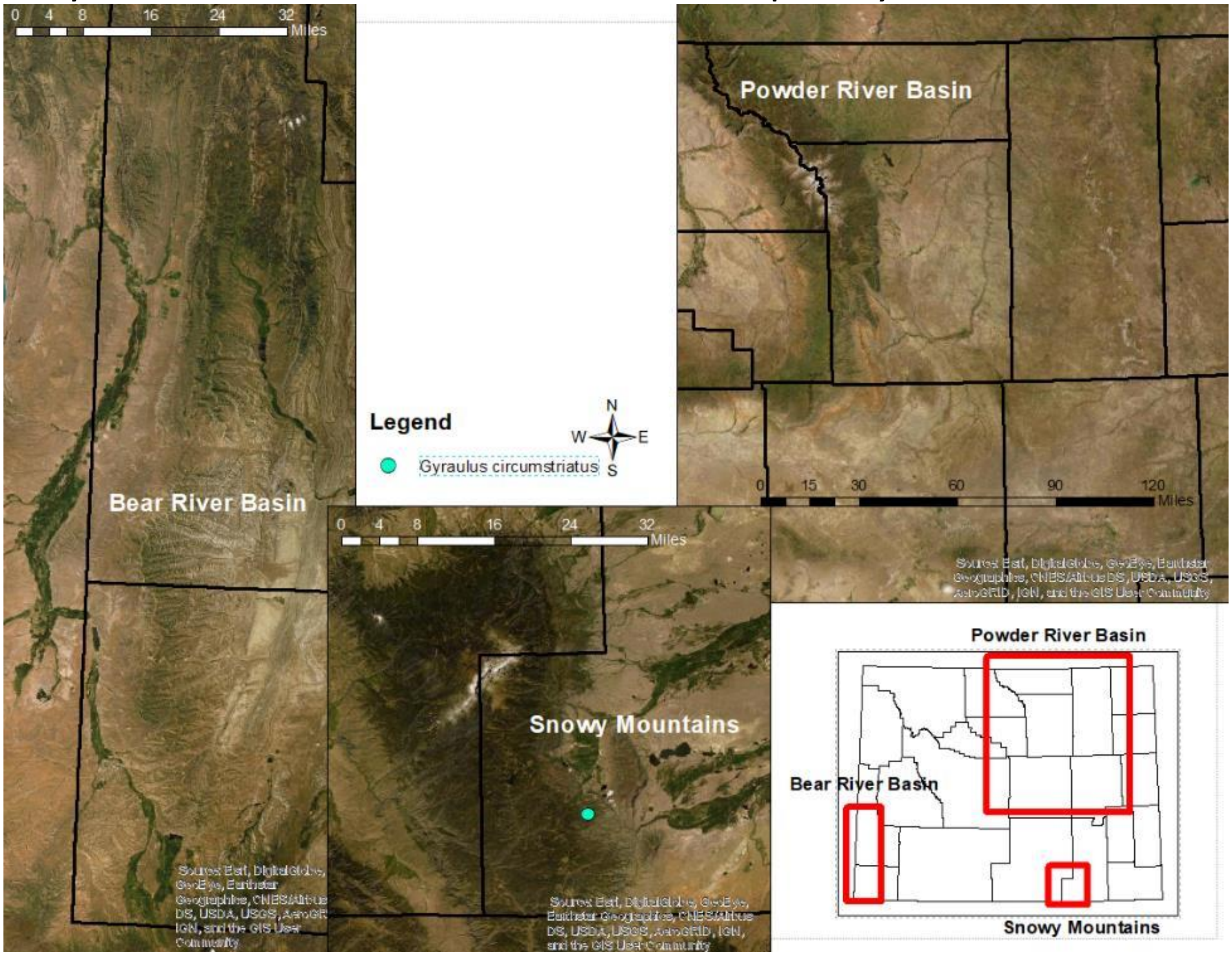


Family Hydrobiidae **Species:** ***Pyrgulopsis pilsbryana***



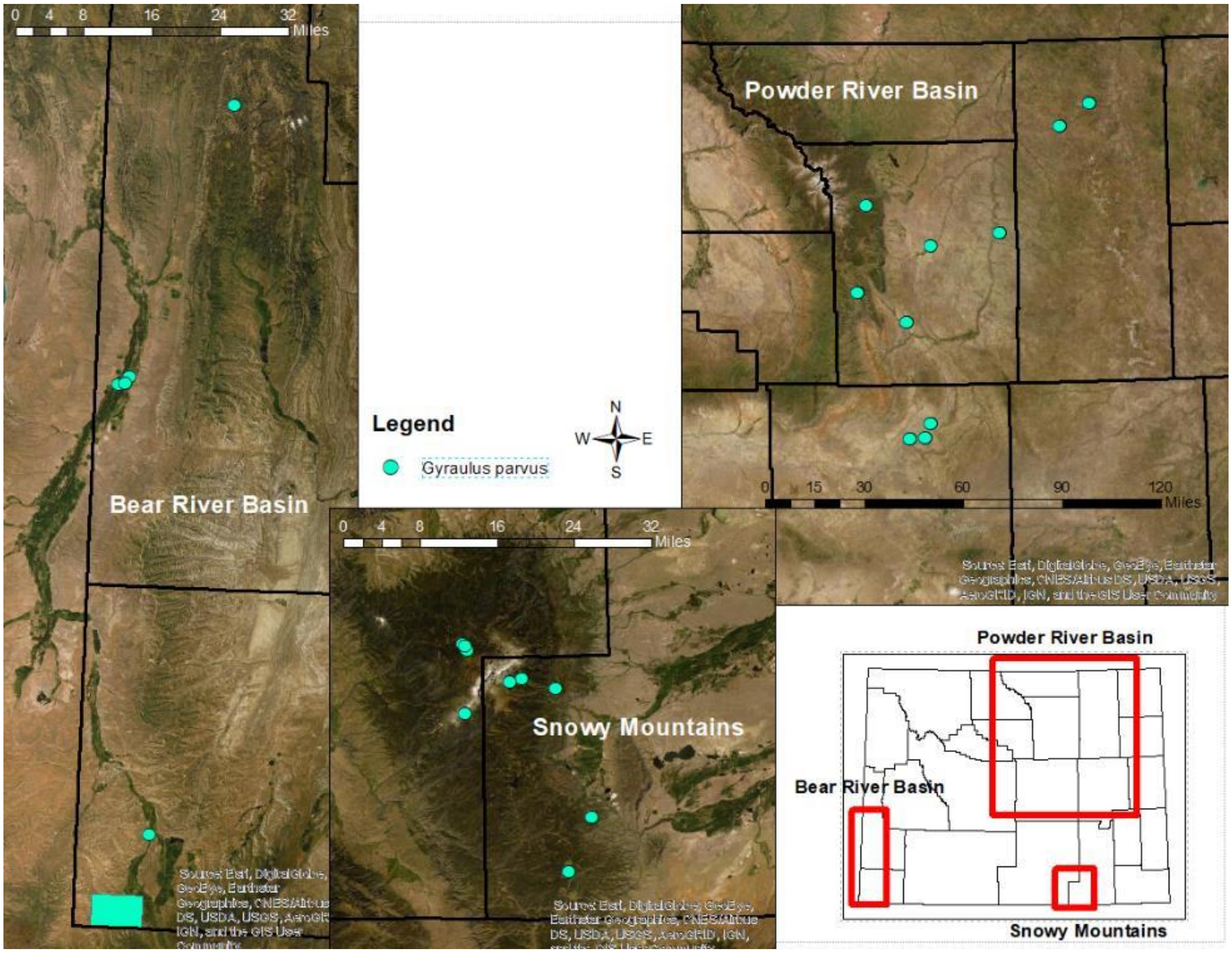
Basins: Bear
Number of sites: 7
Aquatic ecosystem type: Large streams
Substrate: Cobble
Vegetation: Algae
Habitat: Main channel and margin of streams
Ecosystem width: 17.4 m (9.3-21.4)
Size range collected: 2.25-9.0 mm length
CPUE: 1.5 snails/min (0.2-4.4)
Water temperature: 17.0°C (13.7-18.6)
% DO: 120%
DO: 10.5 mg O_2/L (9.1-11.2)
Specific conductivity: 423 µS/cm (237-471)
pH: 8.2 (8.1-8.5)
Oxidation-reduction potential: 131 mV (11.1-191)
Notes: *Pyrgulopsis pilsbryana* is an operculate snail (has gills) that is only known from the Bear River basin in Idaho, Utah and Wyoming. The snail was abundant at some locations.

Family Planorbidae **Species: *Gyraulus circumstriatus***



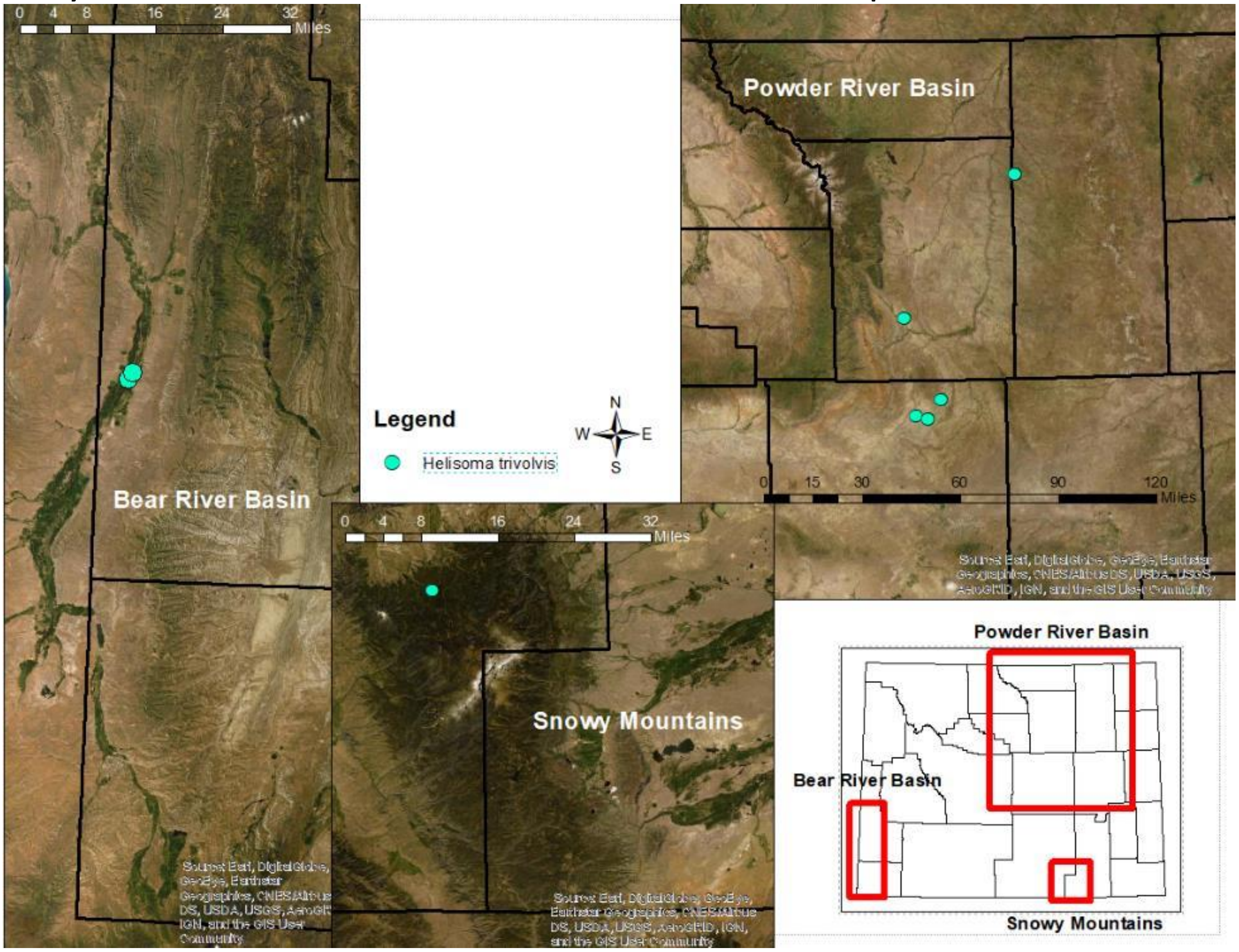
Basins: Snowy Mountains
Number of sites: 1
Aquatic ecosystem type: Lake
Substrate: Cobble
Vegetation: Algae
Habitat: Margin
Ecosystem width: 502 m
Size range collected: 1.5 mm
CPUE: 0.05 snails/min
Water temperature: 15.4°C
% DO: 85%
DO: 8.6 mg O_2/L
Specific conductivity: 63 µS/cm
pH: 8.0
Oxidation-reduction potential: 36 mV
Notes: A small Planorbidae.

Family Planorbidae **Species: *Gyraulus parvus***



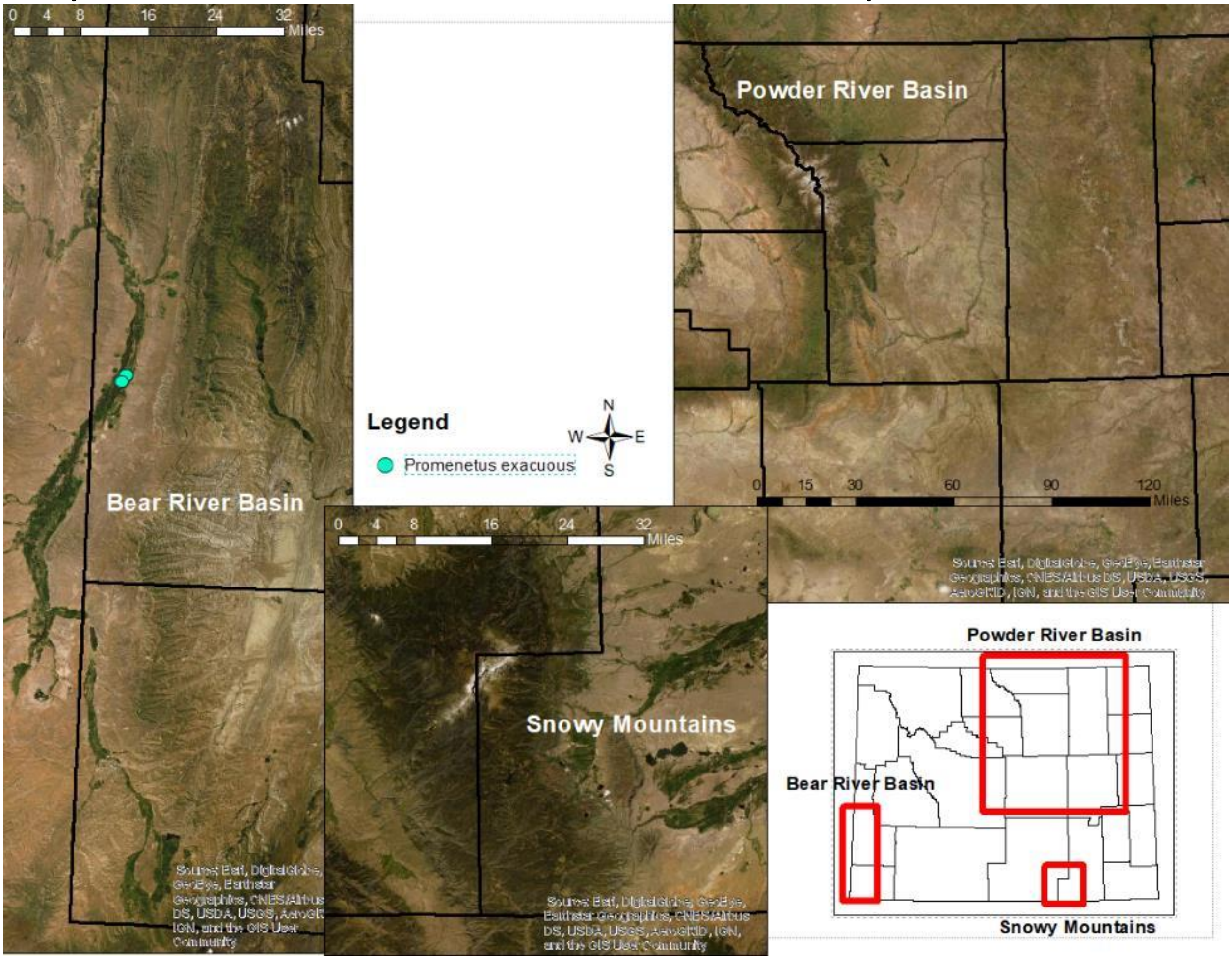
Basins: Bear and Powder River basins, Snowy Mountains
Number of sites: 25
Aquatic ecosystem type: Large streams, springs, wetlands, and lakes
Substrate: Fine substrate, gravel, cobble and wood
Vegetation: Submerged and emergent aquatic vegetation, algae or lacking aquatic vegetation
Habitat: Streams (wood), wetlands and lakes (wood, vegetation, sediments, cobble, margin and open water), and springs (standing water)
Ecosystem width: 135 m (16.8-539.3)
Size range collected: 1-6.5 mm width
CPUE: 0.7 snails/min (0.05-7.1)
Water temperature: 17.9°C (8.5-22.2)
% DO: 87% (19.7-146)
DO: 10.5 mg O_2/L (3-28)
Specific conductivity: 2093 µS/cm (19-8534)
pH: 8.6 (5.0-10)
Oxidation-reduction potential: 19.6 mV (-45.9-132)
Notes: A common Planorbidae snail collected in most aquatic ecosystem types and micohabitats. This small snail appears to be habitat generalist that is widespread across the state.

Family Planorbidae **Species: *Helisoma trivolvis***



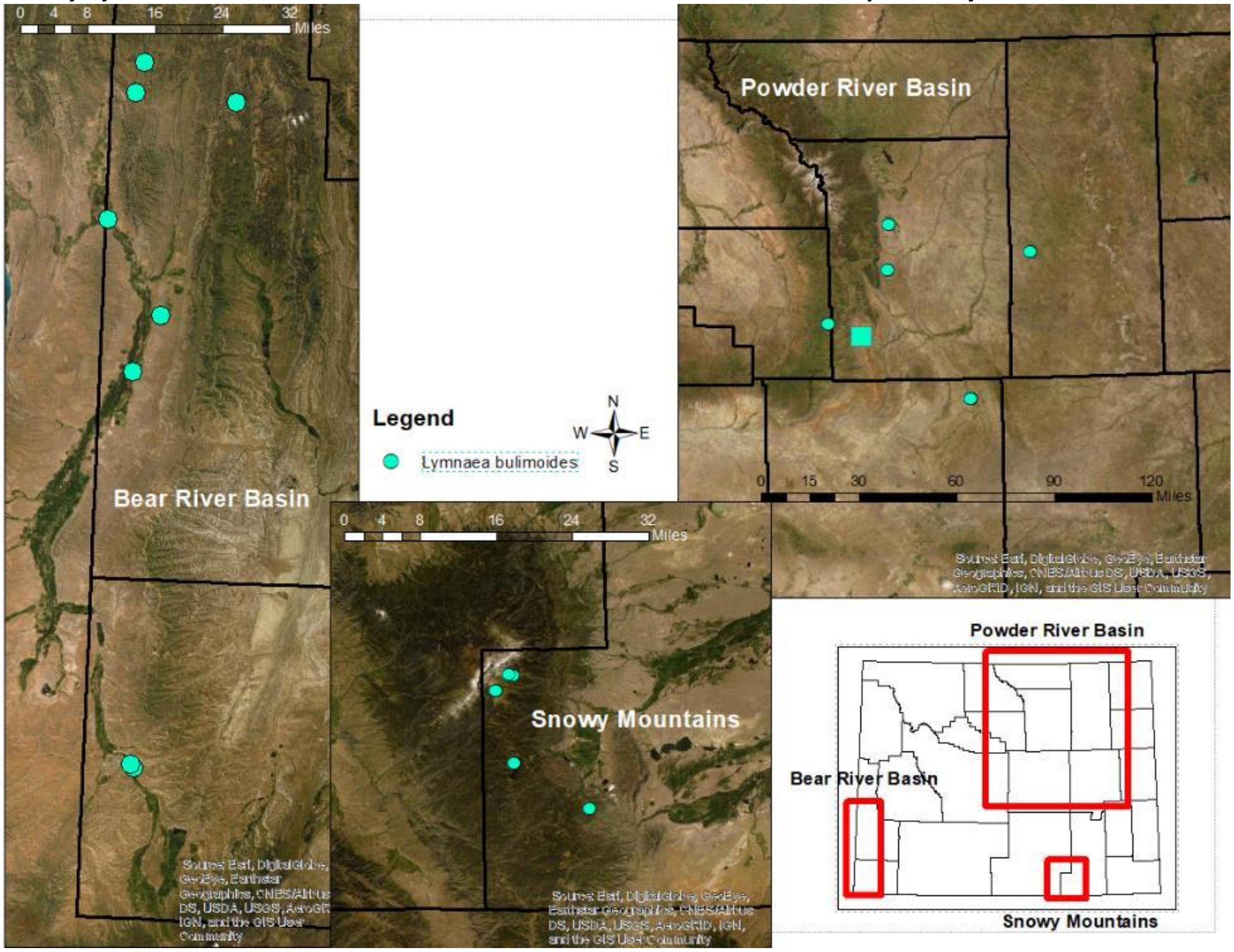
Basins: Bear and Powder River basins, Snowy Mountains
Number of sites: 8
Aquatic ecosystem type: Lakes and wetlands
Substrate: Fine substrate
Vegetation: Submerged and emergent aquatic vegetation, algae or lack of vegetation
Habitat: Margin, open water, sediments, vegetation and wood
Ecosystem width: 73.3 m (16.8-225)
Size range collected: 10-20 mm width
CPUE: 0.4 snails/min (0.1-3.3)
Water temperature: 19.5°C (16.6-25.2)
% DO: 92.5% (24.8-174)
DO: 8.6 mg O_2/L (2.4-13.7)
Specific conductivity: 3747 µS/cm (62.4-14,150)
pH: 8.6 (5.8-9.7)
Oxidation-reduction potential: 11.5 mV (-36-76)
Notes: A large Planorbidae snail collected in lentic aquatic ecosystems.

Family Planorbidae **Species: *Promenetus exacuous***



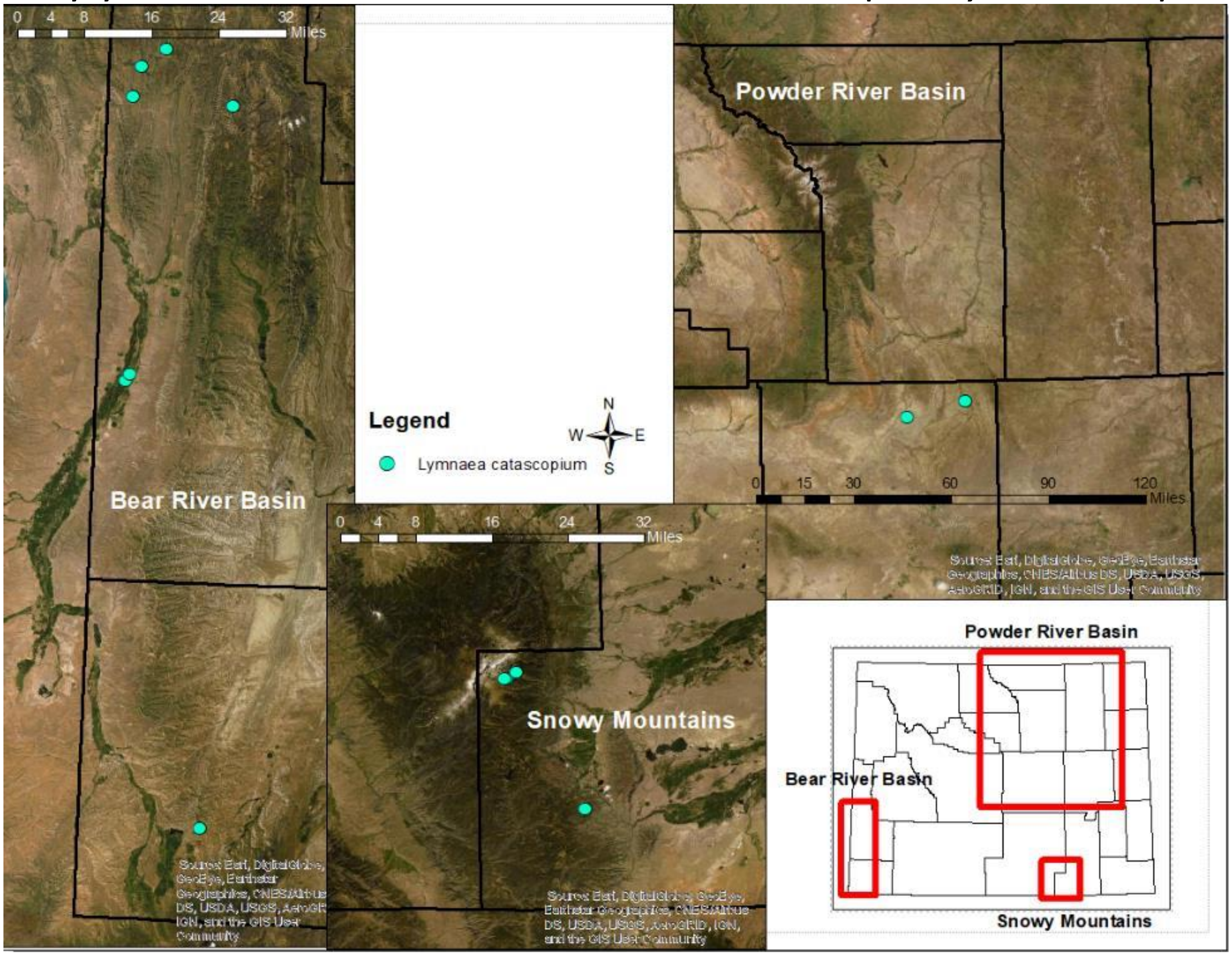
Basins: Bear River basin
Number of sites: 2
Aquatic ecosystem type: Wetlands
Substrate: Fine substrate
Vegetation: Submerged and emergent aquatic vegetation or lacking vegetation
Habitat: Vegetation and wood
Ecosystem width: 40.4 m (16.8-64)
Size range collected: 4-6 mm width
CPUE: 0.33 snails/min (0.1-1.2)
Water temperature: 17.7°C (16.6-18.8)
% DO: 79% (61-96)
DO: 7.5 mg O_2/L (6-8.9)
Specific conductivity: 1365 µS/cm (888-1842)
pH: 8.2 (8.2-8.3)
Oxidation-reduction potential: 71 mV (65-76)
Notes: A small Planorbidae snail collected in wetlands.

Family Lymnaeidae **Species:** ***Lymnaea bulimoides***



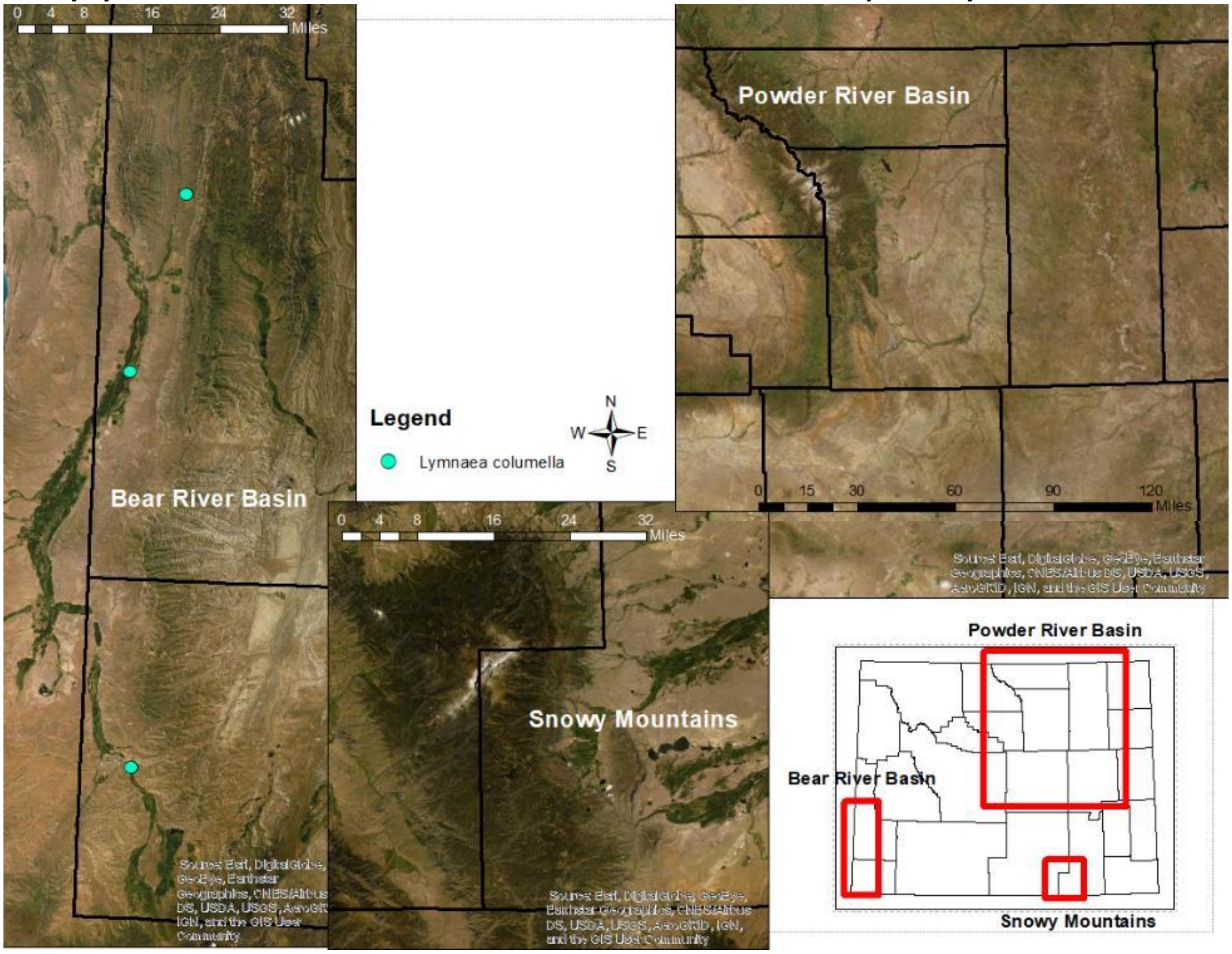
Basins: Bear and Powder River Basins, and Snowy Mountains
Number of sites: 18
Aquatic ecosystem type: Large and small streams, lakes and wetlands
Substrate: Fine substrate, gravel, cobble and wood
Vegetation: Submerged and emergent aquatic vegetation, algae or lacking vegetation
Habitat: Streams (main channel, margin, pool, wood and backwater), wetlands and lakes (sediment, cobble, margin, open water, vegetation and wood)
Ecosystem width: 13 m (0.7-403)
Size range collected: 1-19 mm length
CPUE: 1.1 snails/min (0.05-5.5)
Water temperature: 15.5°C (9.1-20)
% DO: 82.6% (62-120)
DO: 8.5 mg O_2/L (6-11.2)
Specific conductivity: 710 µS/cm (36-9484)
pH: 8.0 (6.7-8.6)
Oxidation-reduction potential: 48 mV (-33-191)
Notes: A small Lymnaeidae snail distinguished from *L. humilis* by the teeth on the radula.

Family Lymnaeidae **Species: *Lymnaea catascopium***



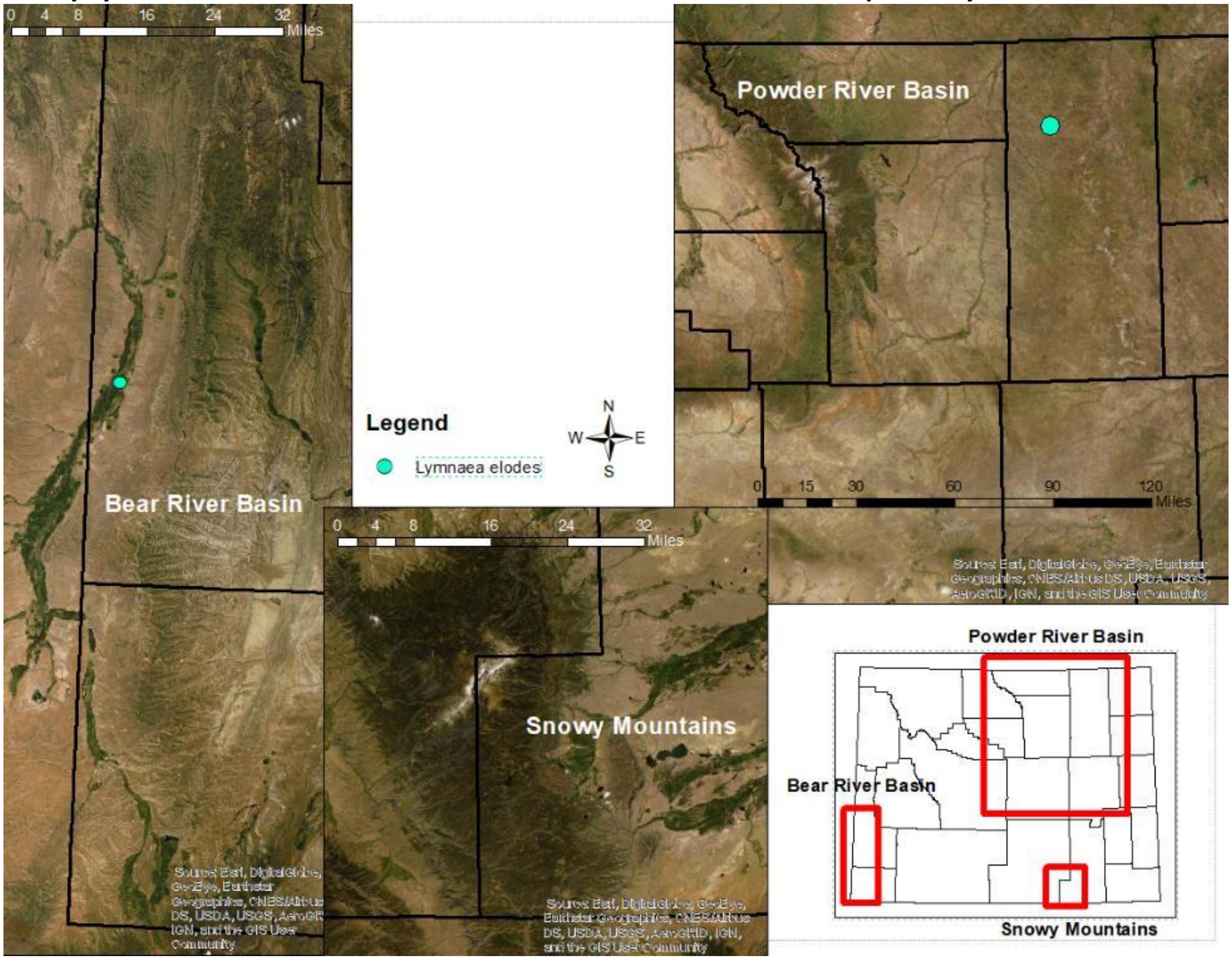
Basins: Bear and Powder River basins, and Snowy Mountains
Number of sites: 12
Aquatic ecosystem type: Large and small streams, lakes and wetlands
Substrate: Fine substrate, cobble and wood
Vegetation: Submerged and emergent aquatic vegetation, algae or lacking vegetation
Habitat: Streams (margin, pool, backwater, cobble and wood), and wetlands and lakes (vegetation, sediments, margin and cobble)
Ecosystem width: 93 m (0.9-502)
Size range collected: 10-27 mm length
CPUE: 0.9 snails/min (0.05-12.8)
Water temperature: 15.6°C (9.1-22.7)
% DO: 85% (61-106)
DO: 8.5 mg O_2/L (6-10.7)
Specific conductivity: 1069 µS/cm (16.5-14,150)
pH: 7.9 (7.3-8.5)
Oxidation-reduction potential: 45.5 mV (-36-99)
Notes: A large Lymnaeidae snail that we observed in lotic and lentic ecosystems. This snail appears to be a habitat generalist.

Family Lymnaeidae **Species: *Lymnaea columella***



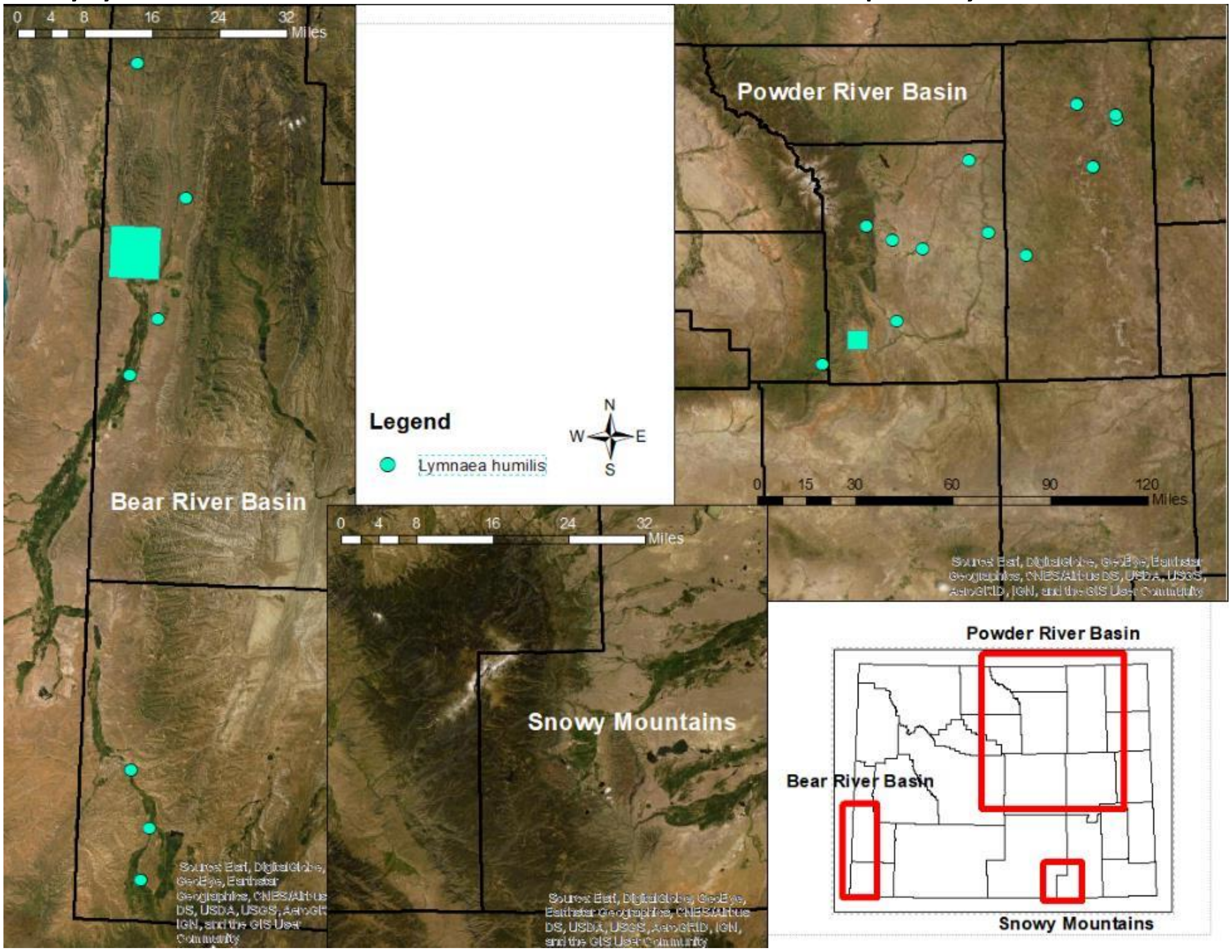
Basins: Bear River basins
Number of sites: 3
Aquatic ecosystem type: Small and large streams, and wetland
Substrate: Fine substrate
Vegetation: Submerged and emergent aquatic vegetation
Habitat: Streams (main channel, backwater and wood) and wetland (wood)
Ecosystem width: 14.5 m (2.1-25.7)
Size range collected: 3-10.5 mm length
CPUE: 0.4 snails/min (0.1-1.2)
Water temperature: 19.5°C (16.6-22.7)
% DO: 85.5% (61-96)
DO: 7.8 mg O_2/L (6-9.1)
Specific conductivity: 367 µS/cm (103-888)
pH: 8.1 (7.8-8.4)
Oxidation-reduction potential: 24 mV (8.1-76)
Notes: An uncommon Lymnaeidae snail.

Family Lymnaeidae **Species:** ***Lymnaea elodes***



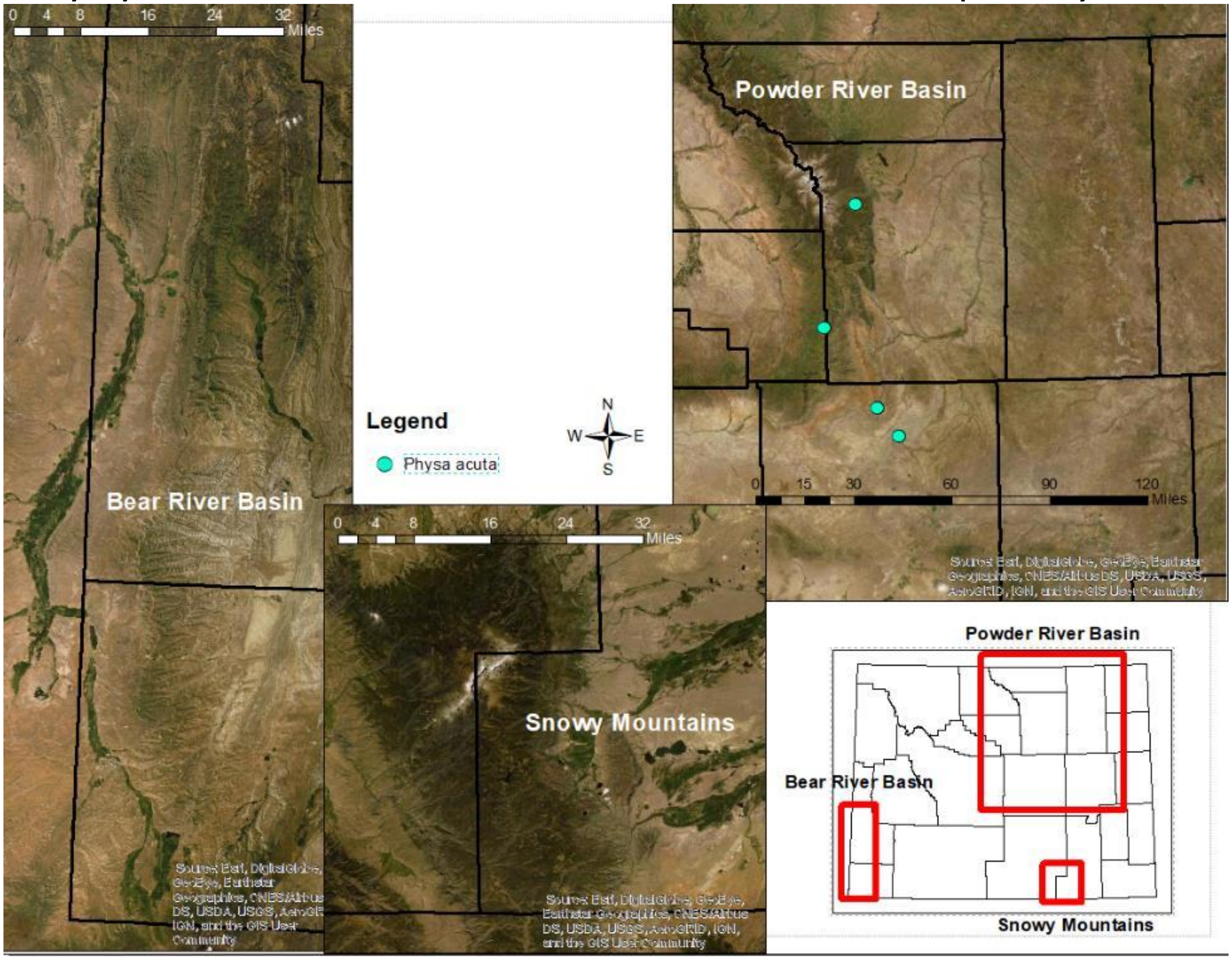
Basins: Bear and Powder River basins
Number of sites: 2
Aquatic ecosystem type: Wetlands
Substrate: Fine substrate and wood
Vegetation: Emergent aquatic vegetation and algae
Habitat: Wetlands (margin and wood)
Ecosystem width: 86 m (64-94)
Size range collected: 10-21 mm length
CPUE: 0.1 snails/min (0.05-0.4)
Water temperature: 17.4°C (16.9-18.8)
% DO: 96%
DO: 4.5 mg O_2/L (3-8.9)
Specific conductivity: 6861 µS/cm (1842-8534)
pH: 8.4 (8.2-8.4)
Oxidation-reduction potential: -18 mV (-46-65)
Notes: A large Lymnaeidae snail that we observed in lentic ecosystems.

Family Lymnaeidae **Species: *Lymnaea humilis***



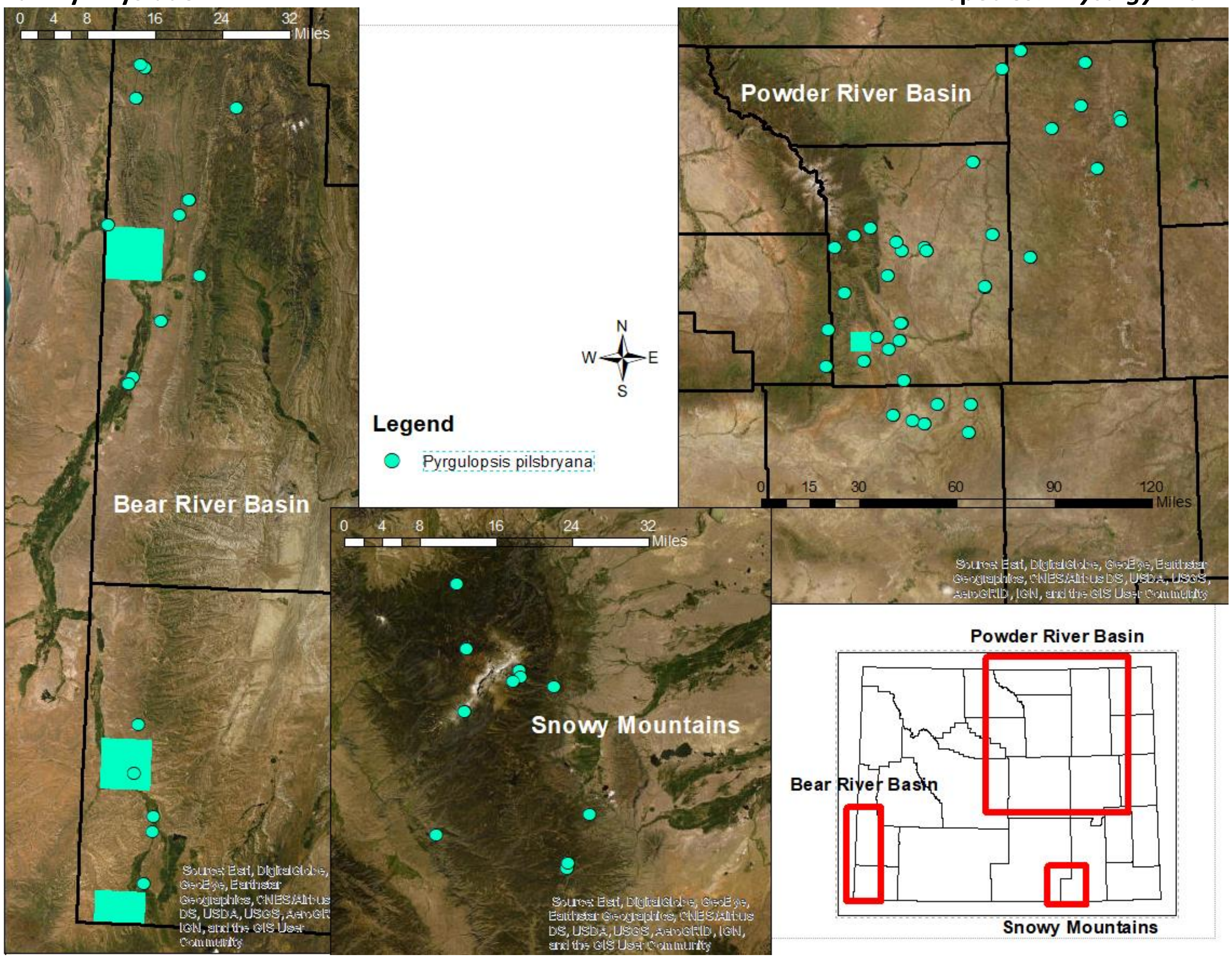
Basins: Bear and Powder River basins
Number of sites: 18
Aquatic ecosystem type: Small and large streams, lake and wetlands
Substrate: Fine substrate, gravel, cobble and wood
Vegetation: Submerged and emergent aquatic vegetation, and algae
Habitat: Streams (main channel, margin, pool, wood and backwater) and lentic (margins, open water, vegetation and wood)
Ecosystem width: 59 m (0.4-502)
Size range collected: 1-11 mm length
CPUE: 0.5 snails/min (0.1-3.2)
Water temperature: 17.1°C (8.1-24)
% DO: 80% (24-108)
DO: 11.2 mg O_2/L (5.5-20.4)
Specific conductivity: 1727 µS/cm (63-4838)
pH: 8.5 (7.8-9.8)
Oxidation-reduction potential: 22 mV (-28-113)
Notes: A small Lymnaeidae snail distinquished from *L. humilis* by the teeth on the radula.

Family Physidae **Species: *Physa acuta***



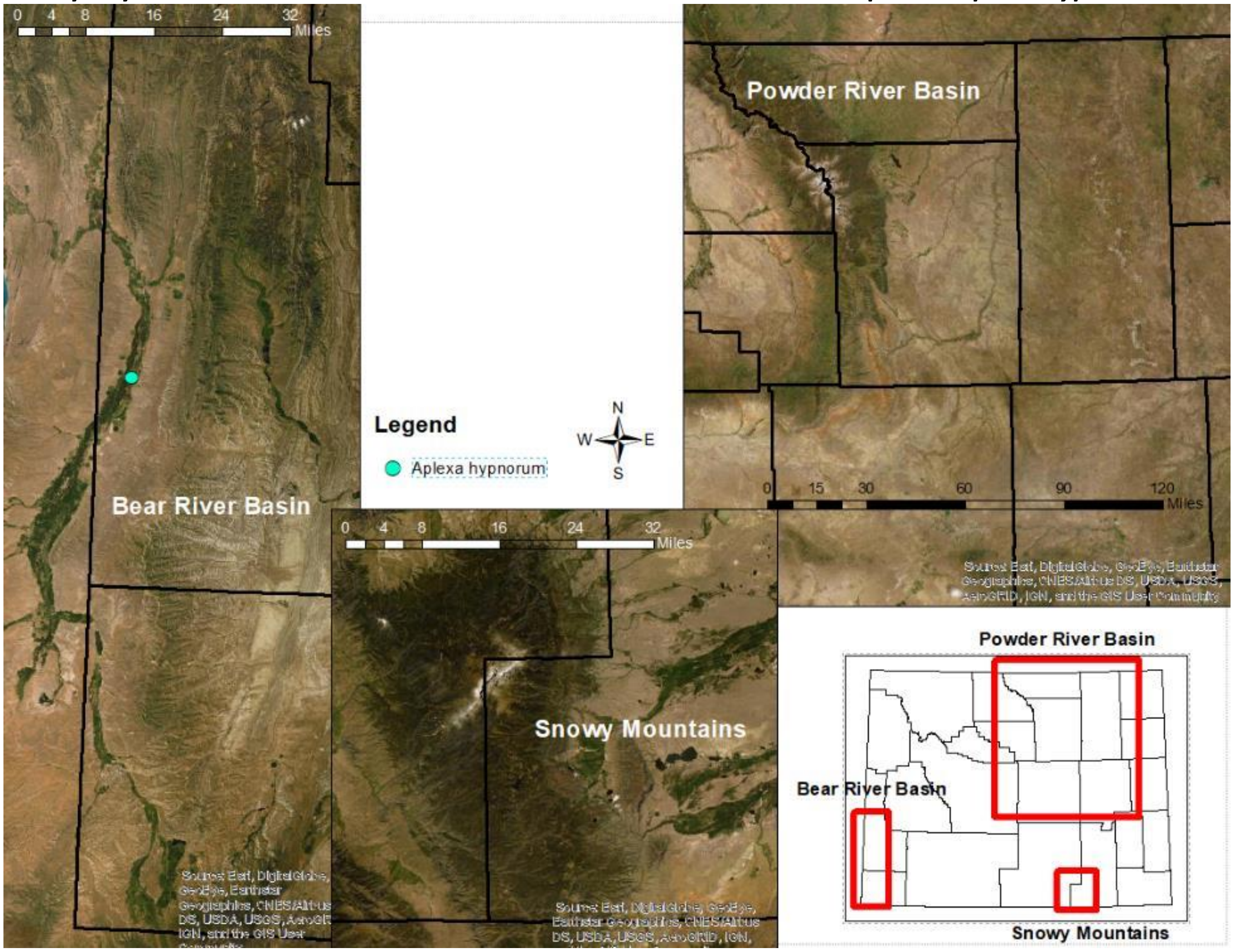
Basins: Powder River basin
Number of sites: 4
Aquatic ecosystem type: Small and large streams, and lakes
Substrate: Fine substrate and cobbles
Vegetation: Submerged and emergent aquatic vegetation and algae
Habitat: Streams (main channel and margin) and lakes (margin, open water and vegetation)
Ecosystem width: 200 m (1.6-539)
Size range collected: 2.5-16 mm length
CPUE: 1.7 snails/min (0.2-6.1)
Water temperature: 14.2°C (8.5-16.9)
DO: 13.0 mg O_2/L (10.1-28)
Specific conductivity: 2181 µS/cm (78-5439)
pH: 9.0 (8.1-10)
Oxidation-reduction potential: 8.2 mV (-0.1-24)
Notes: A large Physidae snail that can live in a range of water quality.

Family Physidae **Species: *Physa gyrina***



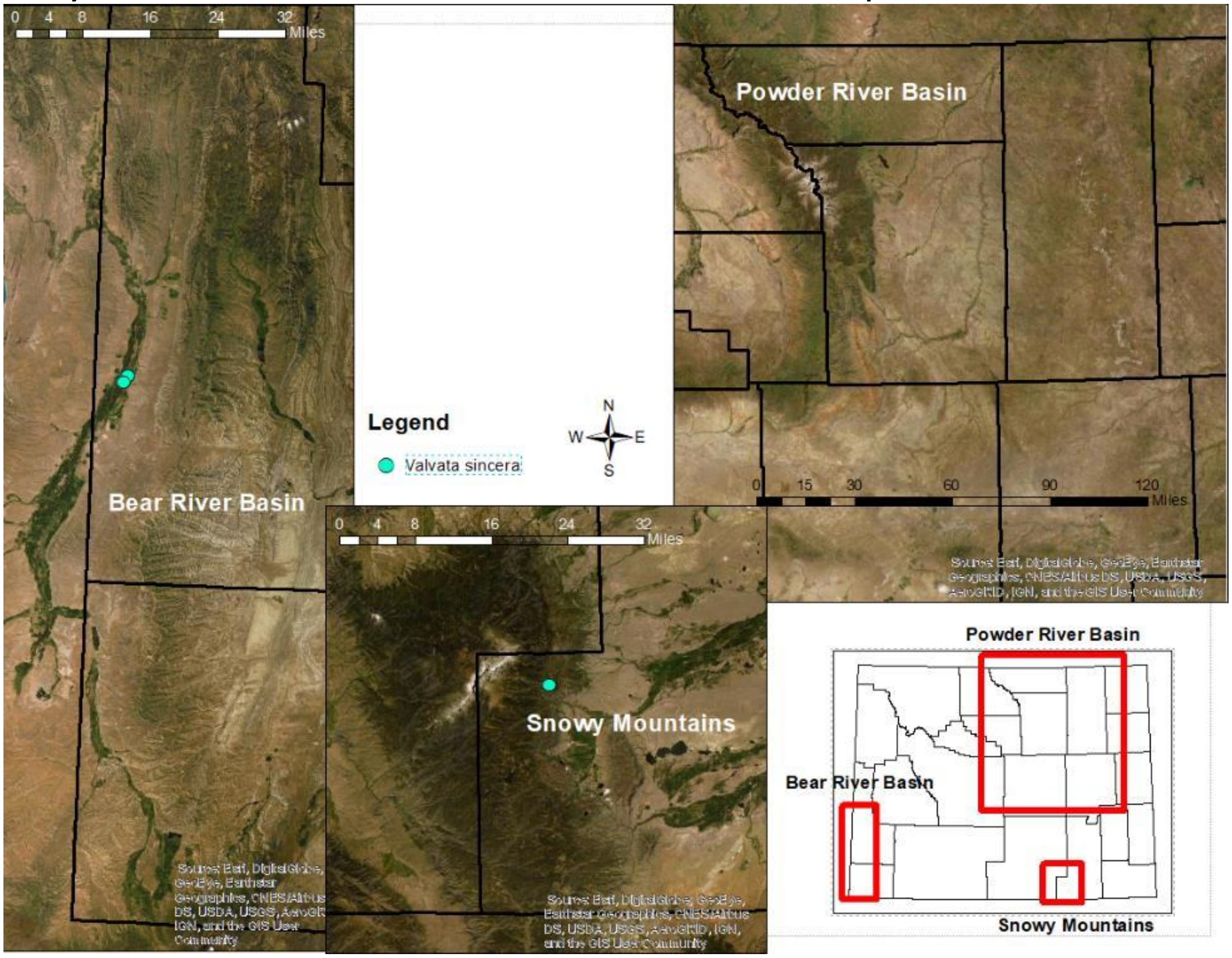
Basins: Bear and Powder River basins, and Snowy Mountains
Number of sites: 69
Aquatic ecosystem type: Large and small streams, springs, lakes and wetlands
Substrate: Fine substrate, gravel, cobble and wood
Vegetation: Submerged and emergent aquatic vegetation, algae and lacking vegetation
Habitat: Streams (main channel, pool, margin, wood, cobble and backwater), wetlands and lakes (vegetation, sediments, cobble, margin, open water and wood), and springs (standing water)
Ecosystem width: 48 m (0.4-247)
Size range collected: 0.75-19 mm length
CPUE: 1.7 snails/min (0.1-14.4)
Water temperature: 16.8°C (6.7-27.5)
% DO: 100% (24-174)
DO: 10 mg O_2/L (3-20)
Specific conductivity: 2245 µS/cm (17.5-14,150)
pH: 8.3 (5.5-9.8)
Oxidation-reduction potential: 27 mV (-48-209)
Notes: A large Physidae snail that lives in all types of aquatic ecosystems and in most microhabitats. The most common Physidae snail encountered.

Family Physidae **Species: *Aplexa hypnorum***



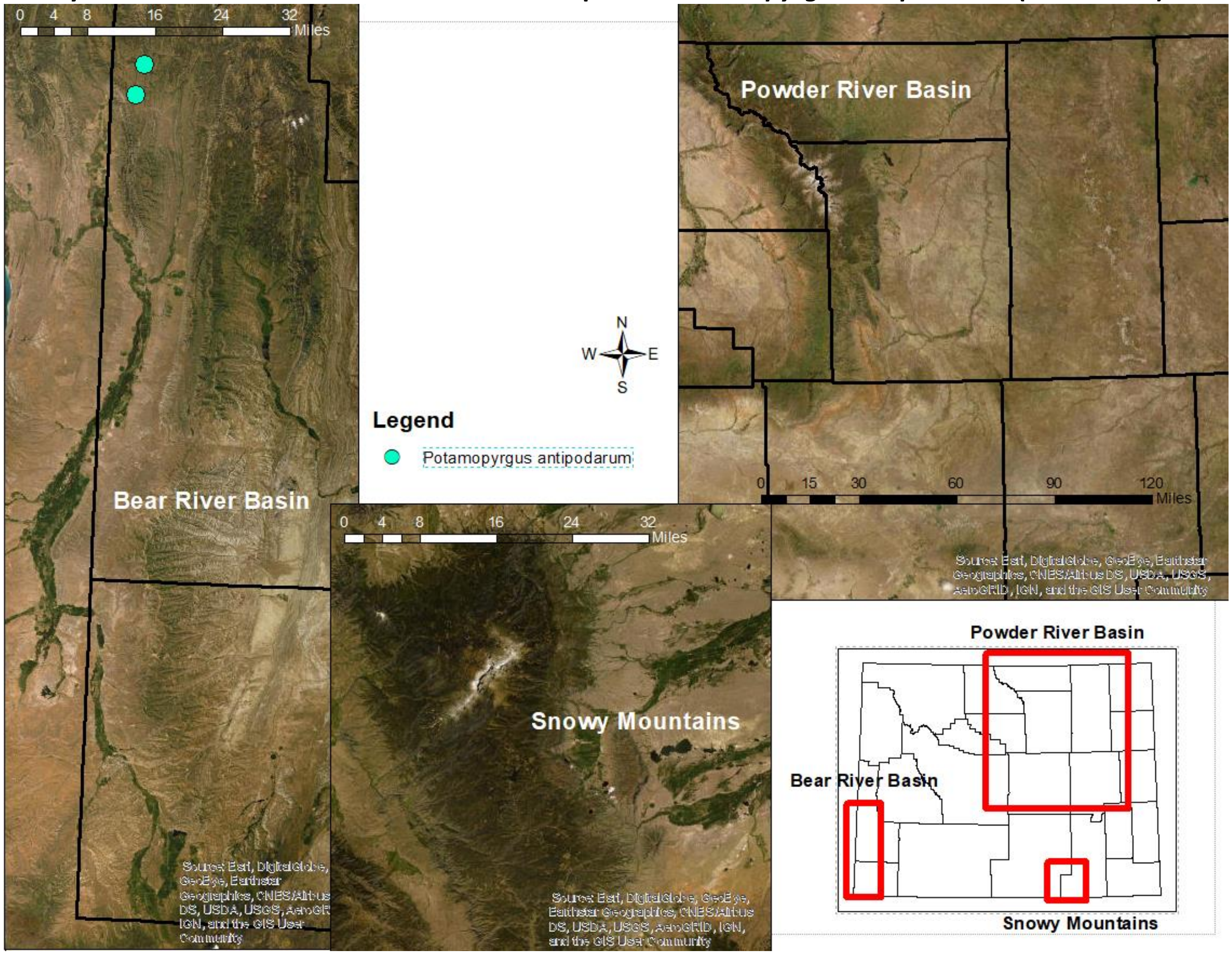
Basins: Bear
Number of sites: 1
Aquatic ecosystem type: Wetland
Substrate: Fine substrate
Vegetation: Emergent aquatic vegetation
Habitat: Wood
Ecosystem width: 16.8 m
Size range collected: 20.5 mm length
CPUE: 0.1 snails/min
Water temperature: 16.6°C
% DO: 61.5%
DO: 6.0 mg O_2/L
Specific conductivity: 888 µS/cm
pH: 8.3
Oxidation-reduction potential: 76 mV
Notes: A unique Physidae snail only found in one wetland. Only a shell was collected.

Family Valvatidae **Species:** ***Valvata sincera***



Basins: Bear River basin and Snowy Mountains
Number of sites: 3
Aquatic ecosystem type: Wetlands and lakes
Substrate: Fine substrate
Vegetation: Submerged and emergent aquatic vegetation, algae and lacking vegetation
Habitat: Sediments, wood and vegetation
Ecosystem width: 68 m (17-140)
Size range collected: 1.5-4 mm length
CPUE: 0.9 snails/min (0.1-3)
Water temperature: 18°C (16.6-18.8)
% DO: 97% (62-146)
DO: 9.2 mg O_2/L (6-13.8)
Specific conductivity: 5984 µS/cm (253-1842)
pH: 8.4 (8.2-8.8)
Oxidation-reduction potential: 54 mV (14-75)
Notes: A rare operculate snail that was only collected at three site.

Family Tateidae **Species: *Potamopyrgus antipodarum* (non-native)**



Basins: Bear
Number of sites: 2
Aquatic ecosystem type: Large streams
Substrate: Fine sediments, cobble and wood
Vegetation: Submerged and emergent aquatic vegetation, and algae
Habitat: Main channel, pool, wood, margin and backwater
Ecosystem width: 6.1 m
Size range collected: 1-4.75 mm length
CPUE: 7.1 snails/min (2.4-11.7)
Water temperature: 9.1°C
DO: 10.7 mg O_2/L
Specific conductivity: 747 µS/cm
pH: 8.4
Oxidation-reduction potential: 99 mV
Notes: A small invasive snail that is parthenogentic (females make copies of themselves). Collected in Salt Creek. Common name is New Zealand Mudsnail.

Discussion

Our study produced information on species of management concern and observations in previously surveyed areas. We discovered the Rocky Mountain Capshell (*Acroloxus coloradensis*), which was previously known from 6 lakes in Colorado, 1 lake in Montana and isolated areas in Canada (Anderson 2005), making this snail a new species to Wyoming. These rare limpets live in mountain lakes with elevations ~2864 m and visible algal biomass (Anderson 2005). We collected the limpet at about 3000 m elevation in a lake with emergent aquatic vegetation and the snails were collected from cobbles. Rocky Mountain Capshells are ranked G3 (vulnerable) throughout their range and S1 (critically imperiled) in Montana and Colorado (NatureServe explorer, www.explorer.natureserve.org). Additionally, we collected the Bear River snail (*Pyrgulopsis pilsbryana*) that is endemic to the Bear River basin at seven sites. These snails were abundant at some of the locations we observed them at. They are ranked G2 (imperiled) through their range, and they are ranked S1 (critically imperiled) in Idaho and Utah (NatureServe explorer, www.explorer.natureserve.org. Our study produced many new records of snails in Wyoming and collected snails in areas that have not previously been sampled. The new information will be incorporated into future State Wildlife Action Plans and is available from the Wyoming Natural Diversity Database so that the information can be used to base management decisions upon.

Several species of invasive mollusks have been discovered in Wyoming and we discovered one species in our surveys. We discovered three non-native species in our survey of the Green and Snake River basins (Tronstad and Andersen 2018), so we are pleased to find fewer non-native species in the Bear and Powder River basins and Snowy Mountains. *Potamopyrgus antipodarum* (New Zealand Mudsnails) are known from a few locations in Wyoming: Pole Cat Creek (Rockefeller Parkway), Firehole River (Yellowstone National Park), Snake River (south of Yellowstone Entrance), in the canyon north of Boysen Reservoir, Green River (inlet of Flaming Gorge Reservoir), in the Shoshone River (east side of Cody; USGS website), Snake River and the Salt River (Tronstad and Andersen 2018). We discovered these invasive snails at 2 sites along Salt Creek in the northern part of the Bear River basin. Like many of the sites where *P. antipodarum* are found, Salt Creek is frequented by fisherman, which may be their source. *Potamopyrgus antipodarum* are parthenogenetic meaning that introducing one individual can recruit a new population, because females reproduce without males. We took precautions between sampling sites by having multiple wading gear, letting wading gear dry, not using felt bottom soles, and cleaning and inspecting gear.

We discovered snails in 53% of the aquatic ecosystems we surveyed. We seldom encountered snails in the Bighorn Mountains, but they were usually found in the basin. The geology in the Bighorn mountains is primarily igneous and metamorphic which slowly weathers, and usually results in lower concentrations of calcium limiting snails. The sedimentary geology in the Powder River basin (lower elevation areas) is likely high in calcium providing the mineral to secrete shells. Additionally, low pH can also impede shell growth because the acidity inhibits shell secretion (Hotchkiss and Hall 2010) and we rarely found snails at sites with pH <7. Snails appeared to be most abundant in ecosystems with higher standing stocks of algae, on substrate (e.g., wood or aquatic vegetation), habitats with slower water velocity (e.g., backwater and margins of streams) and on sediments in wetlands and lakes. Higher standing stocks of algae may support more snails because snails feed on benthic algae potentially indicating higher food availability. Snails were often collected in aquatic vegetation that have very high surface areas and likely provide protection from predators. We collected higher abundances of snails in stream microhabitats with slower water velocities. Commonly, we did not find snails in the main channel of larger streams, but we found them in slower moving water in microhabitats such as the margin or backwater areas. Most snails are probably likely to be swept away at higher water velocities because they carry their shell; however, we often found them on the sides or bottom of cobbles when they did occur in faster water. In lentic ecosystems, we commonly found snails on fine sediments, which was seldom the case in streams with higher water velocities.

Snails can be difficult to identify because most of the keys are out-of-date, only identify individuals to genus or couplets do not separate species. Prior surveys of aquatic snails in Wyoming have suffered from this poor taxonomy and availability of keys. Additionally, shell traits are plastic meaning that the same species can change the shape of their shell because of habitat conditions. For example, snails that live in faster current often have a larger foot, such as *Lymnaea catascopium* that had a larger aperture in large river compared to other ecosystem types we collected them in (L. Tronstad, personal observation). Physa gyrina had larger and rounder shells in lentic habitats compared to streams (L. Tronstad, personal observation). These differences in shell shape have caused a lot of confusion in snail taxonomy over time. We were fortunate to work with Rob Dillon, a snail expert in North America who has studied these creatures his entire career. With his help, we made a functioning key with up-to-date taxonomy which we updated in this report with photos and clearer language. Based on Rob's expert knowledge, he grouped some species together (e.g., *Stagnicola apicina*, *S. bonnevillensis*, *S. catascopium*, *S. hinkleyi* and *S. montanensis* now under *Lymnaea catascopium*) and identified species that may occur in Wyoming that have not been observed (e.g., Table 1). Many of the species he grouped could not be distinguished from one another and no molecular data was available to support their species status. For example, *Stagnicola bonnevillensis* was a Candidate species under the Endangered Species Act until 2009 when it was removed from the list because the species was discovered to be much more widely distributed. We expect that snail taxonomy will change further, and we will update the key as changes occur. Having a standardized key with which to identify snails is advancing our knowledge of these animals in Wyoming and enabling us to have current data on which to base management decisions.

Acknowledgements
We thank Michelle Weschler, Sasha Maxey and Tresize Tronstad for assistance in the field. Dr. Rob Dillon developed the key to identify Wyoming snails and we are grateful to his assistance. The Fisheries Division of the Wyoming Game and Fish Department provided funding for the project and I appreciate their patience during a very turbulent time in my life.

Literature Cited

Anderson, T. 2005. Rocky Mountain Capshell Snail (*Acroloxus coloradensis*): a technical conservation assessment. Prepared for the USDA Forest Service, Rocky Mountain Region, Species Conservation Project. Available at: http://www.fs.fed.us/r2/projects/scp/assesskejts/rockymountaincapshellsnail.pdf

Beetle, D. E. 1989. Checklist of recent Mollusca of Wyoming, USA. Great Basin Naturalist 49:637-645.

Galat, D.L., C.R. Berry, E.J. Peters and R.G. White. 2005. Missouri River Basin. In: Rivers of North America edited by A. C. Benke and C. E. Cushing. Pp. 427-480. Academic Press, New York.

Hotchkiss, E. R. and R. O. Hall. 2010. Linking calcification by exotic snails to stream inorganic carbon cycling. Oecologia 163:235-244.

Lenth, R. 2021. emmeans: estimated mearginal means, aka least-squares means

Limm, M.P. and M.E. Powers. 2011. Effects of western pearlshell mussel Margaritifera falcata on Pacific lamprey Lampretra tridentata and ecosystem processes. Oikos 120:1076-1082.

Luppens, J.A., D.C. Scott, L.M. Osmonson, J.E. Haacke and P.E. Pierce. 2013. Assessment of coal geology, resources, and reserve base in the Powder River Basin, Wyoming and Montana. USGS Fact Sheet 2012-3143.

Lydeard, C., R. H. Cowie, W. F. Ponder, A. E. Bogan, P. Bouchet, S. A. Clark, K. S. Cummings, T. J. Frest, O. Gargominy, D. G. Herbert, R. Hershler, K. E. Perez, B. Roth, M. Seddon, E. E. Strong and F. G. Thompson. 2004. The global decline of nonmarine mollusks. BioScience 54:321-330.

Mathias, P.T. 2014a. Native freshwater mussel surveys of the North Platte and South Platte river drainages, Wyoming. Wyoming Game and Fish Department Report.

Mathias, P.T. 2015a. Native freshwater mussel surveys of the Powder-Tongue, Belle Fourche, and Cheyenne river drainages, Wyoming. Wyoming Game and Fish Department Report.

Mathias, P.T. 2014b. Native freshwater mussel surveys of the Bear and Snake river drainages, Wyoming. Wyoming Game and Fish Department Report.

Mathias, P.T. 2015b. Native freshwater mussel surveys of the Wind and Bighorn drainages, Wyoming. Wyoming Game and Fish Department Report

Narr, C. 2011. Habitats of snails and snails as habitats. Thesis. University of Wyoming.

Ponder, W. F. and D. Lunney, editors. 1999. The Other 99%: The Conservation and Biodiversity of Invertebrates. Mosman (Australia): Royal Zoological Society of New South Wales.

R Core Development Team. 2017. R: Language and environment for statistical computing. R Foundation for Statistical Computing. Vienna.

Shiozawa, D.K. and R.B. Rader. 2005. Great Basin Rivers. In: Rivers of North America edited by A. C. Benke and C. E. Cushing. Pp. 655-694. Academic Press, New York.

Tronstad, L.M. and P.T. Mathias. 2015. Status of the mussels in the Belle Fourche and Laramie Rivers at Devils Tower National Monument and Fort Laramie National Historic Site. Report prepared by the Wyoming Natural Diversity Database for the National Park Service. Available at: wyndd.org/reports/

Tronstad, L.M. and M.D. Andersen. 2018. Aquatic snails of the Snake and Green River basins of Wyoming. Report prepared by the Wyoming Natural Diversity Database for the Wyoming Game and Fish Department. Available at: wyndd.org/reports/

Tronstad, L.M., M. Crawford and T. Rodgers. 2021. Using eDNA to estimate the distribution of the California Floater (Anodonta californiensis/nuttalliana clade) and Western Pearlshell (Margaritifera falcata) mussels in the Bear River basin of Wyoming. Report prepared by the Wyoming Natural Diversity Database for the Wyoming Game and Fish Department. Available at: wyndd.org/reports/

Vaughn, C.C. and C.C. Hakenkamp. 2001. The functional role of burrowing bivalves in freshwater ecosystems. Freshwater Biology 46:1431-1446.

Wickham, H. 2011. The split-apply-combine strategy for data analysis. Journal of Statistical Software 40:1-29.

Wickham, H. 2016. Ggplot2: elegant graphics for data analysis. Springer-Verlag New York.

Wilmot, O.J., P.T. Mathias and L.M. Tronstad. 2017. Wyoming native freshwater mussel surveys: 2015-2016. Report prepared by the Wyoming Natural Diversity Database for the Wyoming Game and Fish Department.

Wilmot, O.J., L.M. Tronstad, S. Siddons, M. Murphy and B. Fitzpatrick. 2019. Using eDNA to guide surveys for Plain Pocketbook and Giant Floater mussels in Wyoming. Report prepared by the Wyoming Natural Diversity Database for the Wyoming Game and Fish Department.

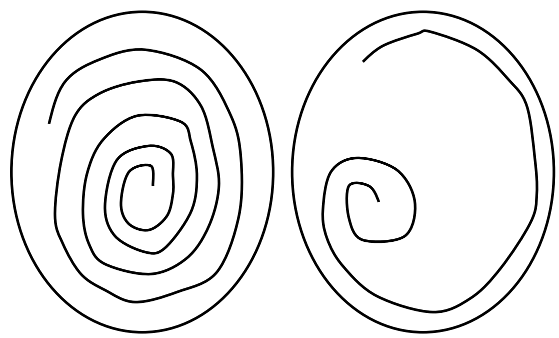
Appendix 1. Key to the Freshwater Gastropods of Wyoming (version 2)

Rob Dillon, Bryan Tronstad and Lusha Tronstad
Direct questions to Lusha Tronstad, Invertebrate Zoologist, Wyoming Natural Diversity Database, University of Wyoming, tronstad@uwy.edu, 307-766-3115

1a) Operculum present. . . . . . Subclass Prosobranchia (2)

1b) Operculum absent . . . . . . Subclass Pulmonata (10)

2a) Operculum multi spiral (Valvatidae) . . . . (3)



Multi spiral

Pauci spiral

2b) Operculum pauci spiral. . . . . . . (4)

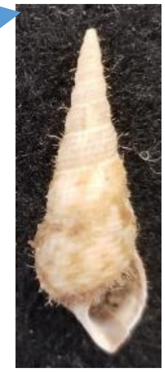
*Remove operculum and view with transmitted light from below

3a) Shell smooth, without carination (ridges) … *Valvata sincera*

3b) Shell with a single carina (ridge), becoming obsolete … *Valvata utahensis*

3c) Shell with three spiral carinae (ridges) … *Valvata tricarinata*

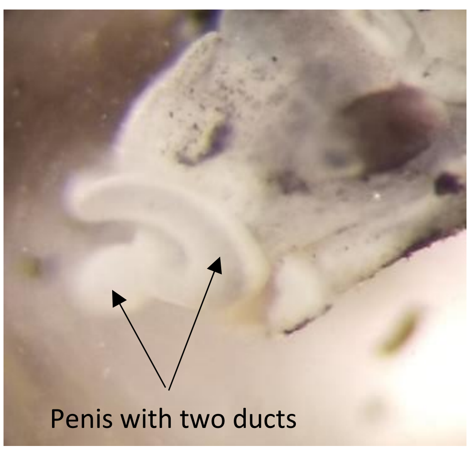
4a) Adults >12 mm shell length, all female, ovoviviparous brooders (Thiaridae) . . . *Melanoides tuberculata*



4b) Adults <12 mm shell length, sexes separate (Hydrobiod taxa) . . . . . (5)

5a) Penis with a single duct under mantel . . . (6)

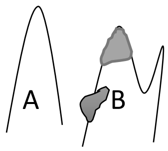
5b) Penis with two ducts under mantel (Amnicolidae) . . . (9)



5c) Males rare or entirely absent, females parthenogenic, usually full of embryos (live bearers), length ≤6 mm . . . *Potamopyrgus antipodarum*

6a) Penis simple, with a single duct (**A**). Inhabits rocky riffles (Lithoglyphidae) . . . (7)

6b) Penis with a single duct and a glandular (grey on drawing), terminal lobe (**B**; Hydrobiidae) … (8)



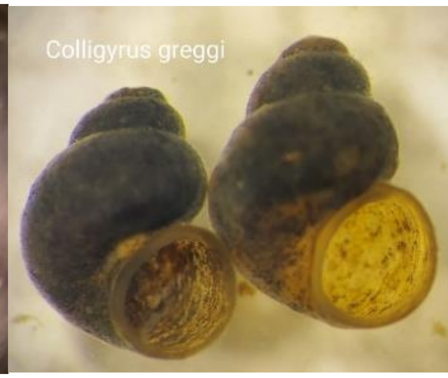
7a) Snake River drainage … *Fluminicola coloradoensis* (via Lui et al. 2013)

7b) Green River drainage … *Fluminicola coloradoensis*

8a) Dorsal surface of penis bearing an elongated gland extending from the base of a filament. Snake River drainage … *Pyrgulopsis robusta*

8b) Bear River drainage… *Pyrgulopsis pilsbryana*

9a) Adult shell length ~3 mm, sutures notched. Snake and Bear River Basin … *Colligyrus greggi*

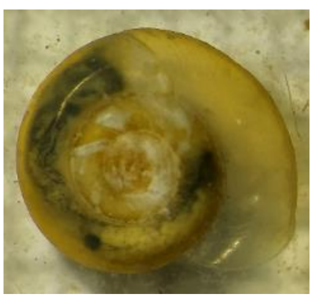


9b) Adult shell length 4 – 5 mm, shell sutures not notched. Widespread in lentic waters throughout North America … *Amnicola limosa*

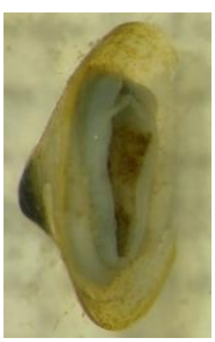
10a) Shell dextral (opens to the right) . . . Family Lymnaeidae (11)

10b) Shell sinistral (opens to the left), not planispiral . . . Family Physidae (17)

10c) Shell sinistral, planispiral (flattened). . . Family Planorbidae (21)



10d) Shell patelliform (pyramid shaped) . . . (28)



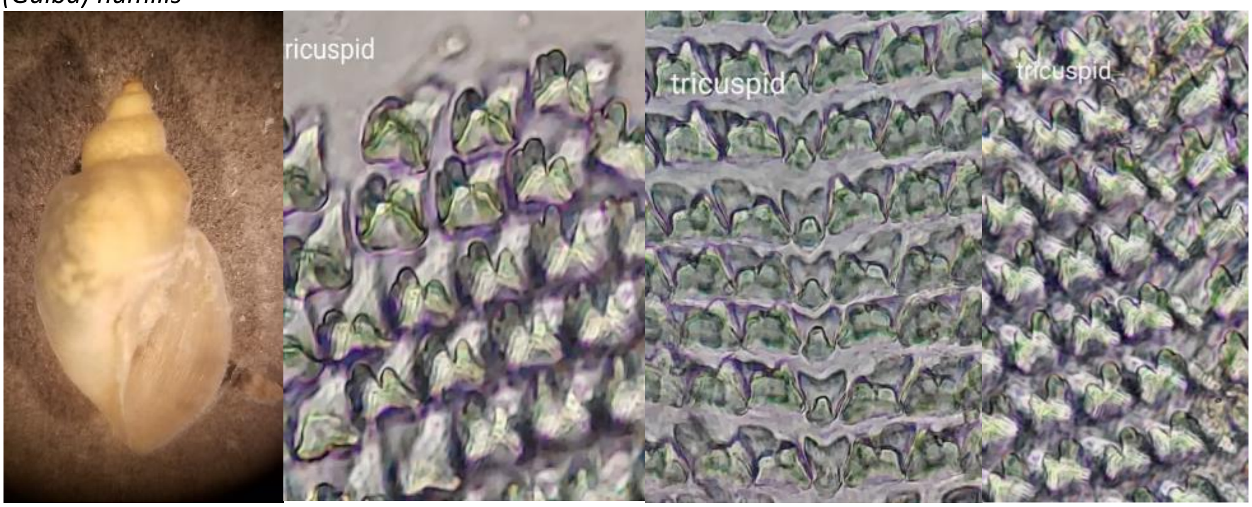
Lymnaeidae

11a) Adult shell ≤17 mm length, often on mud above water (≥4 whorls) … (12)

11b) Adult shell between 13 and 35 mm length, apex not concave, various habitat … (13)

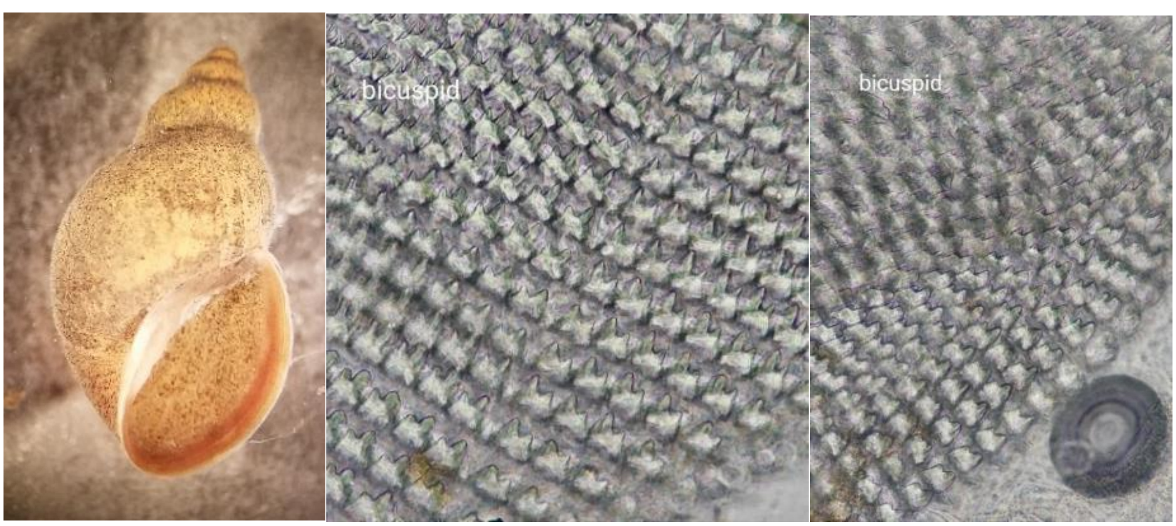
11c) Adult shell >35 mm length, apex concave, lakes … *Lymnaea stagnalis*

12a) Adult shell narrow, usually <13 mm standard length, lateral teeth of radula tricuspid … *Lymnaea (Galba) humilis*



*Removal buccal cavity from foot, dissolve in bleach and examine with 400x under compound microscope

12b) Adult shell broader, rounded, often >10 mm standard length, lateral teeth of radula bicuspid … *Lymnaea (Galba) bulimoides*



13a) Shell sturdy, aperture ≤60% of shell length … (14)

13b) Shell fragile, aperture >60% of shell length … (16)

14a) Shell sculptured with fine periostracal ridges (fuzz at apex) … *Lymnaea (Galba) caperata*

14b) No periostracal ridges… (15)

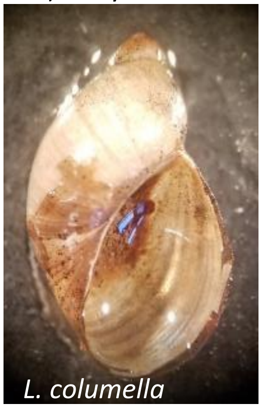
15a) Shell with relatively small body whorl … *Lymnaea (Stagnicola) elodes*

L. elodes

15b) Shell with relatively large body whorl, lateral teeth of radula bicuspid … *Lymnaea (Stagnicola) catascopium*

L. catascopium

16a) Body whorl moderately expanded … *Lymnaea (Pseudosucinea) columella*



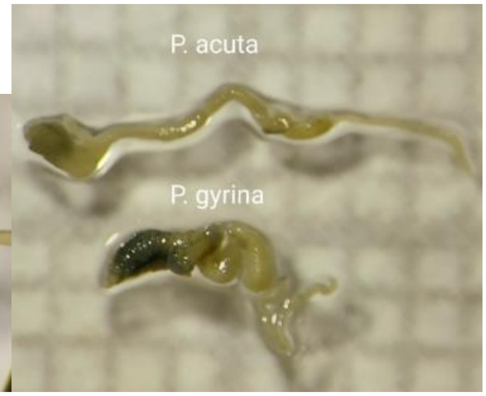
16b) Body whorl globose (inflated) … *Lymnaea (Radix) auricularia*

Physidae

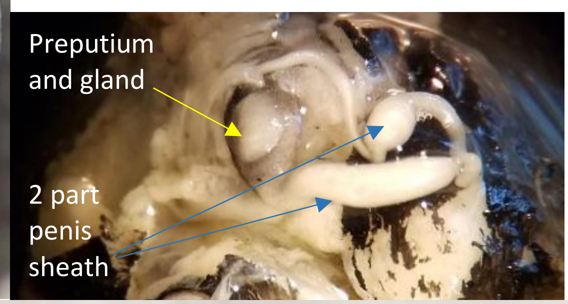
17a) Shell slender, glossy. Penis lacks a preputial gland. Ditches, vernal habitats . . . *Aplexa hypnorum*

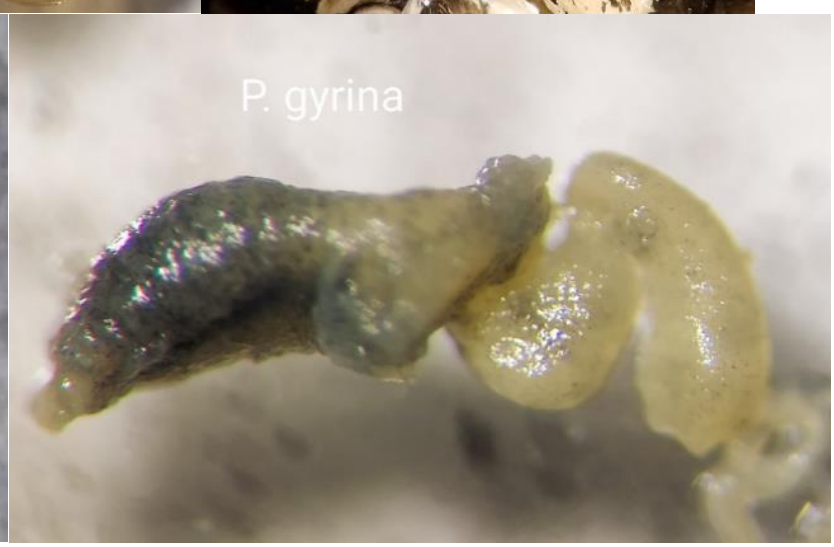
17b) Shell unremarkable, habitat unremarkable, penis bearing a preputial gland . . . (18)

18a) One-part penial sheath … (19)



18b) Two-part penial sheath. Shell apex notably convex. Widespread, but generally in nutrient-poor waters … *Physa gyrina*





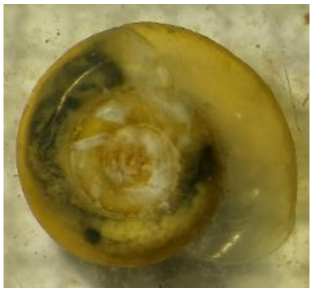
19a) One-part, glandular penial sheath. Adult sizes smaller. Shell apex convex-ish.   Enlarged mantle enfolds the shell. Mountain lakes and ponds . . . *Physa jennessi*

19b) One-part, muscular penial sheath. Shell apex concave … (20)

20a) Cosmopolitan, especially in rich, disturbed habitats, apex concave . . . *Physa acuta*

20b) Snake River, but otherwise indistinguishable … *Physa columbiana* (taxonomy?)

20c) Just that one cave … *Physa spelunca*



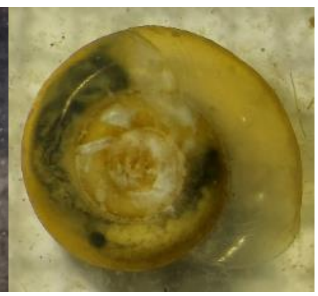
Planorbidae

21a) Adult shell small, <8 mm diameter … (22)

21b) Adult shell larger than 8 mm diameter … (26)

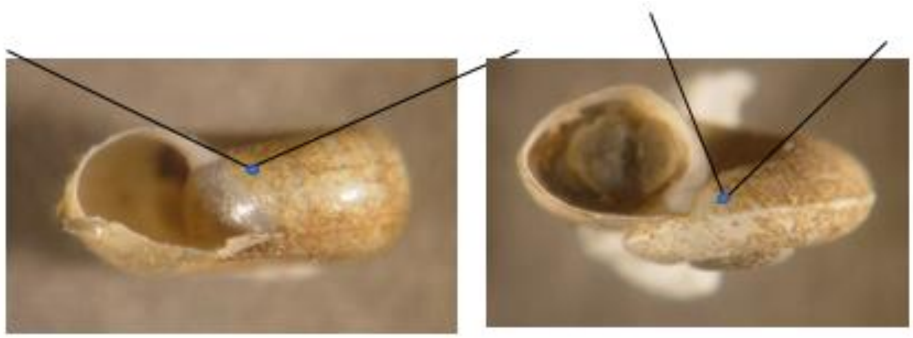
22a) Shell costate (ridges) … Gyraulus crista

22b) Shell not costate (lacks ridges) … (23)



23a) Spire pit shallow and wide, >45 degrees … (24)

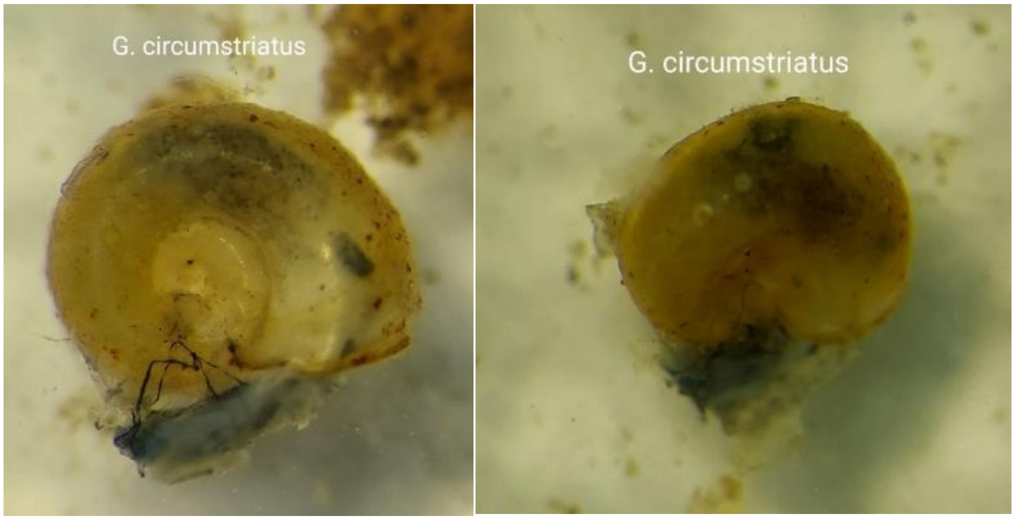
23b) Spire pit deep and narrow, <45 degrees … (25)



Gyraulus, spire pit > 45 degrees   Menetus, spire pit < 45 degrees

- Blue dot is bottom of spire pit, which you can only see by looking down into the pit itself

24a) Top and bottom of shell nearly identical, whorls increase uniformly in size … *Gyraulus circumstriatus*



24b) Top and bottom of shell differ, whorls increase more rapidly with size … *Gyraulus parvus*

25a) Shell periphery rounded … *Promenetus umbilicatellus*

25b) Shell periphery weakly angular, distinctly off mid-whorl … *Menetus operularis*

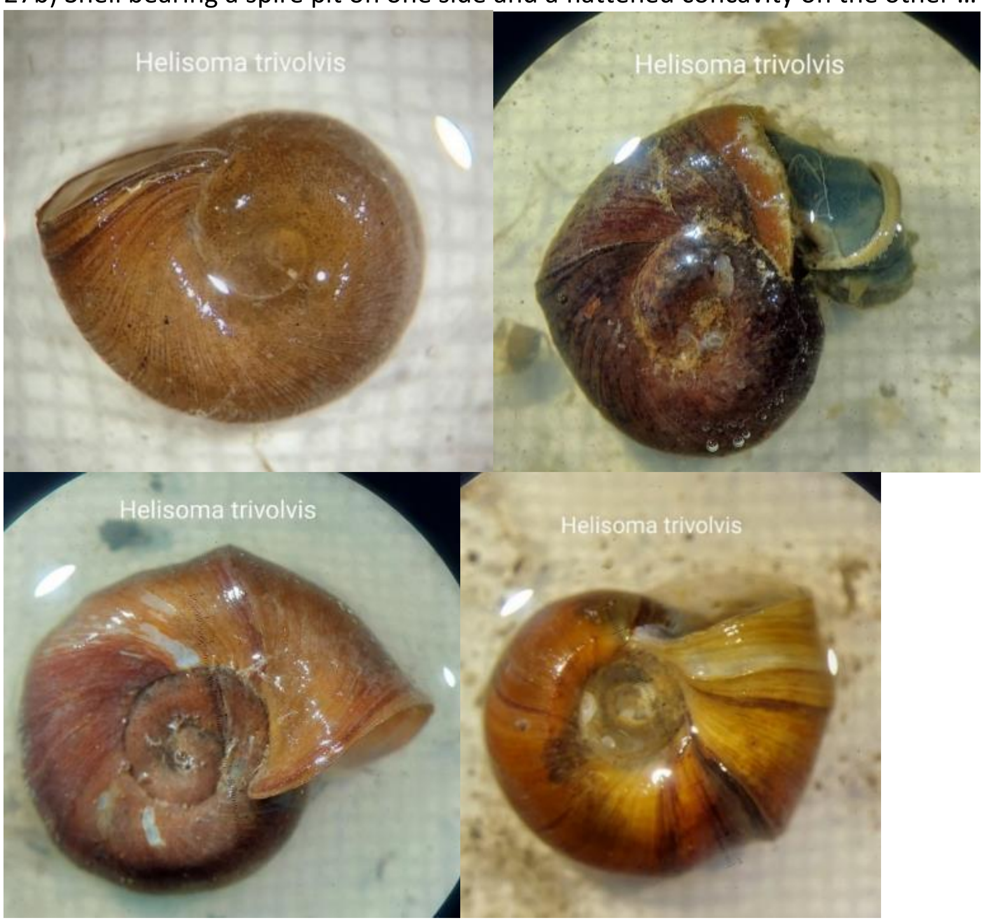
25c) Shell periphery strongly carinate (ridged), approximately mid-whorl … *Promenetus exacuous*

26a) Shell compressed, thin and weak … *Planorbula campestris*

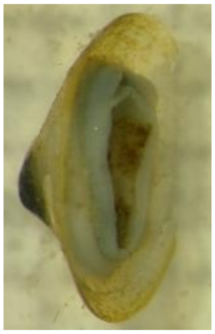
26b) Shell broad, too solid to crush accidentally … (27)

27a) Shell deeply pitted when viewed from either aspect … *Helisoma anceps*

27b) Shell bearing a spire pit on one side and a flattened concavity on the other … *Helisoma trivolvis*



27c) Shell bearing a spire pit on one side and an apparent “apex” on the other … *Helisoma (Carinifex) newberryi*

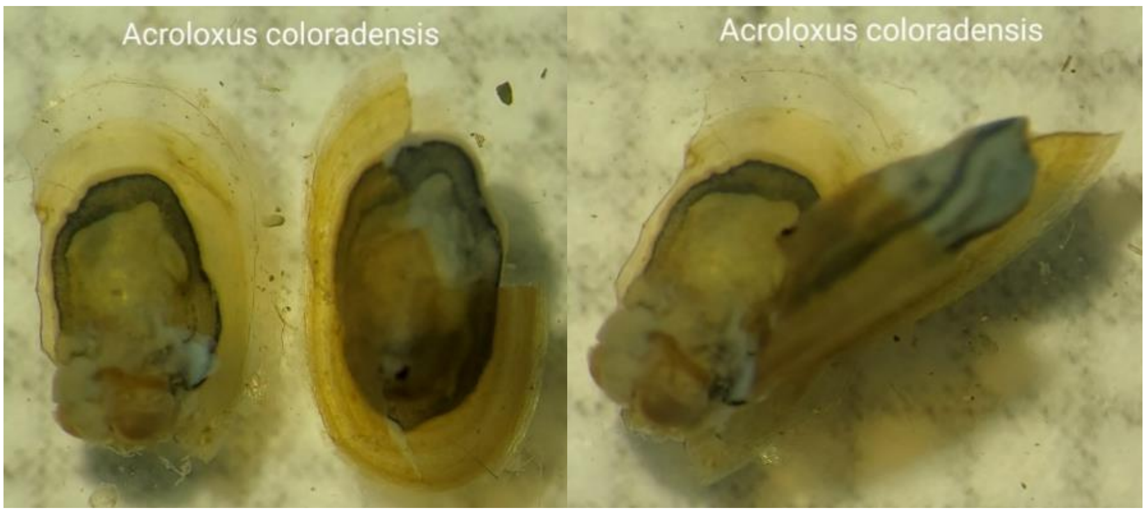


Limpets

28a) Adult shell larger than 7 mm, Snake River basin (a patelliform lymnaeid) … *Fisherola nuttalli*

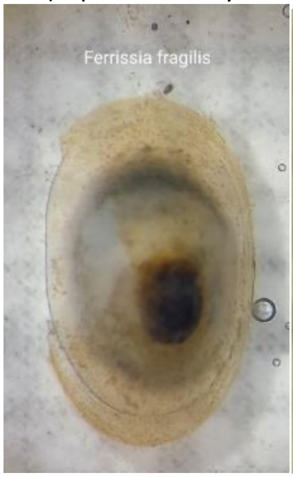
28b) Adult shell smaller than 7 mm … (29)

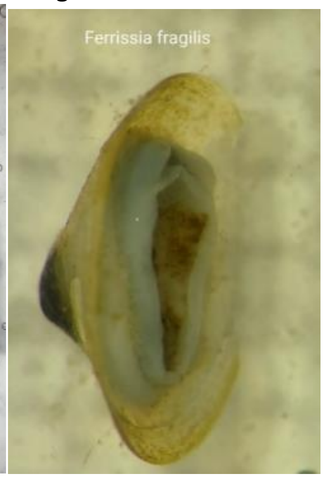
29a) Apex acute, to the left of midline, habitat high mountain lakes (Acroloxidae) … *Acroloxus coloradensis*



29b) Apex low, not acute, cosmopolitan habitat … (30)

30a) Apex distinctly to the right of the midline . . . *Ferrissia fragilis*

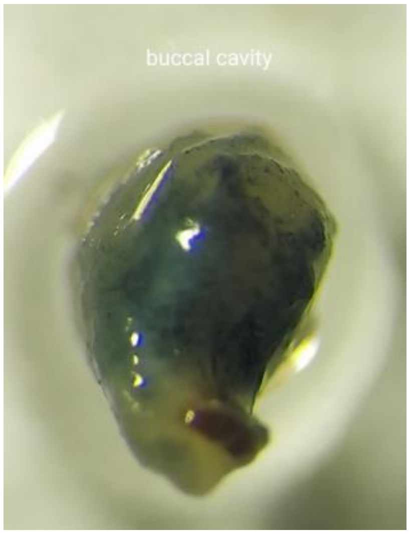




30b) Apex approximately in the midline . . . *Ferrissia rivularis*

Identifying bicuspid or tricuspid teeth of the lateral teeth of the radula

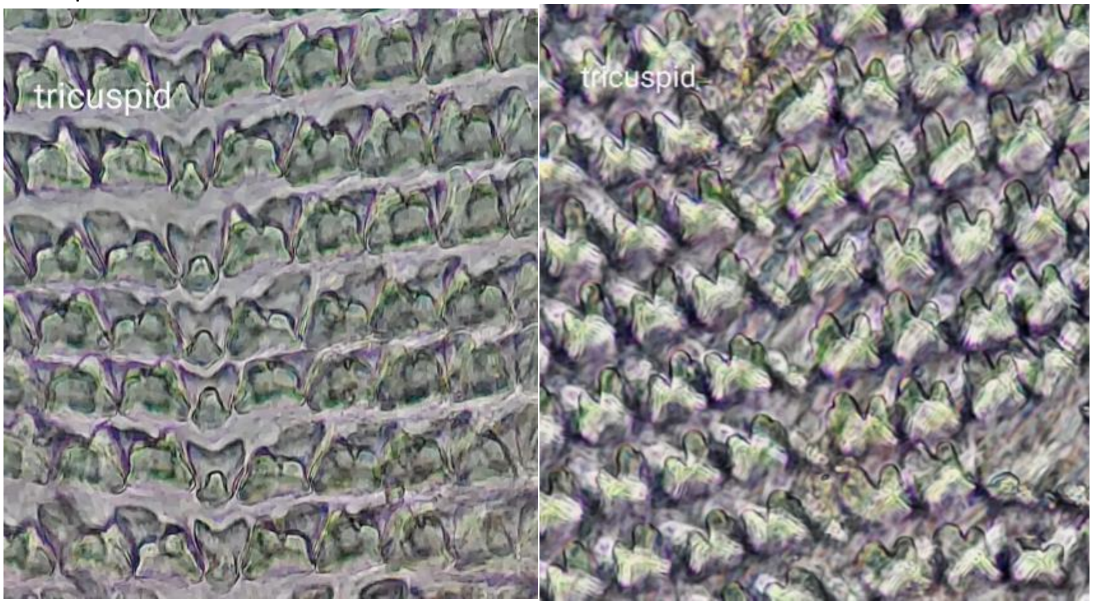
1. Remove buccal cavity from the inside of the snail's foot. Buccal cavity is a round sack that is inside the snail foot and is connected to the bottom surface of the foot.



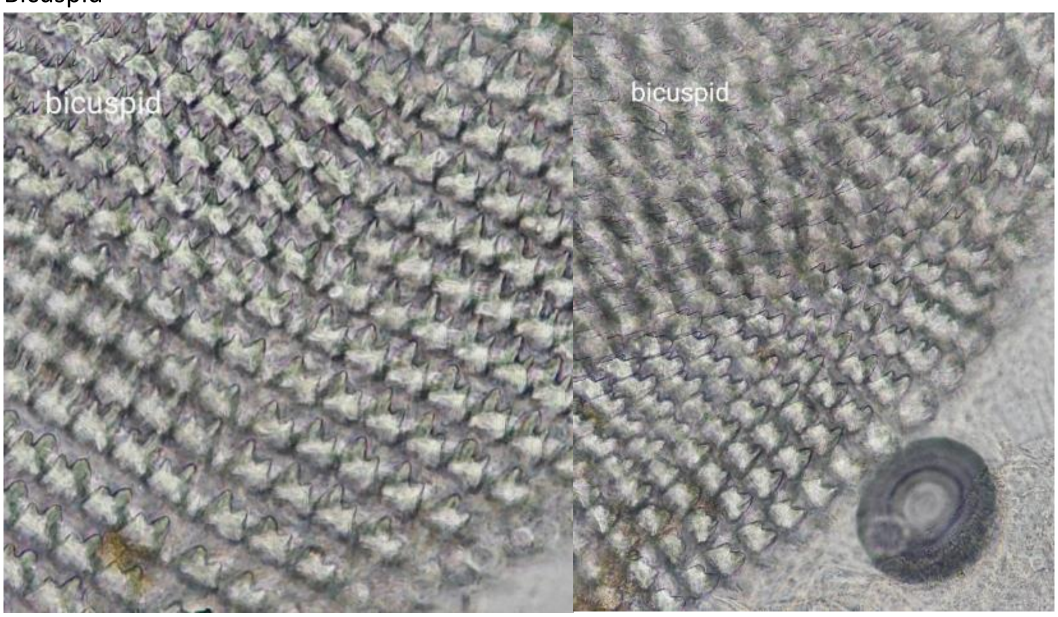
2. Submerge buccal cavity in a small dish of 100% bleach until fleshy material has dissolved and all that is left is the teeth of the radula. When you see bubbles forming around the buccal cavity you know the bleach is working. Keep an eye on the dissolving buccal cavity and remove the teeth from the bleach solution as soon as all fleshy material is dissolved. This process can take between 5 and 30 minutes depending on the size of the buccal cavity.

3. Next place a drop of water on a slide and place the teeth in the center of the water. Flatten the teeth out on the slide and place a cover slip on top. Then examine the teeth on both sides of the center line using a 400x compound microscope. Tricuspid teeth will show 3 points and bicuspid teeth will have 2 points.

Tricuspid



Bicuspid



Appendix 2. Snail taxonomy in Wyoming with synonymies. Valid names with a question mark indicate that the species has not been collected in Wyoming, but they may occur in the state. An asterisk indicates the species is not native to Wyoming.

Family	Valid Scientific Name	Former Names
Acroloxidae	*Acroloxus coloradensis*	*Acroloxus coloradensis*
Ancylidae	*Ferrissia fragilis*	*Ferrissia fragilis*
Ancylidae	*Ferrissia rivularis*	*Ferrissia rivularis*
Amnicolidae	*Amnicola limosa*	*Amnicola limosa*
Amnicolidae	*Colligyrus greggi*	*Colligyrus greggi*
Lithoglyphidae	*Fluminicola coloradoensis*	*Fluminicola coloradoensis*
Lithoglyphidae	*Fluminicola fuscus*	*Fluminicola coloradoensis*
Hydrobiidae	*Pyrgulopsis pilsbryana*	*Pyrgulopsis pilsbryana*
Hydrobiidae	*Pyrgulopsis robusta*	*Pyrgulopsis robusta*
Lymnaeidae	*Fisherola nuttalli* (?)	*Fisherola nuttalli*
Lymnaeidae	*Lymnaea auricularia**	*Radix auricularia*
Lymnaeidae	*Lymnaea bulimoides*	*Galba bulimoides*
Lymnaeidae	*Lymnaea caperata*	*Stagnicola caperata*
Lymnaeidae	*Lymnaea catascopium*	*Stagnicola apicina*
Lymnaeidae	*Lymnaea catascopium*	*Stagnicola bonnevillensis*
Lymnaeidae	*Lymnaea catascopium*	*Stagnicola catascopium*
Lymnaeidae	*Lymnaea catascopium*	*Stagnicola hinkleyi*
Lymnaeidae	*Lymnaea catascopium*	*Stagnicola montanensis*
Lymnaeidae	*Lymnaea columella*	*Pseudosuccinea columella*
Lymnaeidae	*Lymnaea elodes*	*Stagnicola elodes*
Lymnaeidae	*Lymnaea elodes*	*Stagnicola traski*
Lymnaeidae	*Lymnaea humilis*	*Galba dalli*
Lymnaeidae	*Lymnaea humilis*	*Galba modicella*
Lymnaeidae	*Lymnaea humilis*	*Galba obrussa*
Lymnaeidae	*Lymnaea humilis*	*Galba parva*
Lymnaeidae	*Lymnaea stagnalis*	*Lymnaea stagnalis*
Physidae	*Aplexa hypnorum*	*Aplexa elongata*
Physidae	*Physa acuta*	*Physa acuta*
Physidae	*Physa acuta*	*Physella mexicana*
Physidae	*Physa columbiana*	*Physella columbiana*
Physidae	*Physa gyrina*	*Physa ancillaria*
Physidae	*Physa gyrina*	*Physa gyrina*
Physidae	*Physa gyrina*	*Physa gyrina utahensis*
Physidae	*Physa gyrina*	*Physella cooperi*
Physidae	*Physa gyrina*	*Physella propinqua*
Physidae	*Physa jennessi*	*Physa megalochlamys*
Physidae	*Physa jennessi*	*Physa skinneri*
Physidae	*Physa spelunca*	*Physa spelunca*
Planorbidae	*Gyraulus circumstriatus*	*Gyraulus circumstriatus*

Family	Valid Scientific Name	Former Names
Planorbidae	*Gyraulus crista*	*Gyraulus crista*
Planorbidae	*Gyraulus parvus*	*Gyraulus parvus*
Planorbidae	*Helisoma anceps*	*Helisoma anceps*
Planorbidae	*Helisoma newberryi*	*Helisoma newberryi*
Planorbidae	*Helisoma trivolvis*	*Planorbella duryi*
Planorbidae	*Helisoma trivolvis*	*Planorbella scalaris*
Planorbidae	*Helisoma trivolvis*	*Planorbella subcrenata*
Planorbidae	*Helisoma trivolvis*	*Planorbella trivolvis*
Planorbidae	*Menetus opercularis*	*Menetus opercularis*
Planorbidae	*Planorbula campestris*	*Planorbula campestris*
Planorbidae	*Promenetus exacuous*	*Promenetus exacuous*
Planorbidae	*Promenetus umbilicatellus*	*Promenetus umbilicatellus*
Tateidae	*Potamopyrgus antipodarium**	*Potamopyrugus antipodarium*
Thiaridae	*Melanoides tuberculate**	*Melanoides tuberculatus*
Valvatidae	*Valvata humeralis*	*Valvata humeralis*
Valvatidae	*Valvata sincera*	*Valvata sincera*
Valvatidae	*Valvata tricarinata*	*Valvata tricarinata*