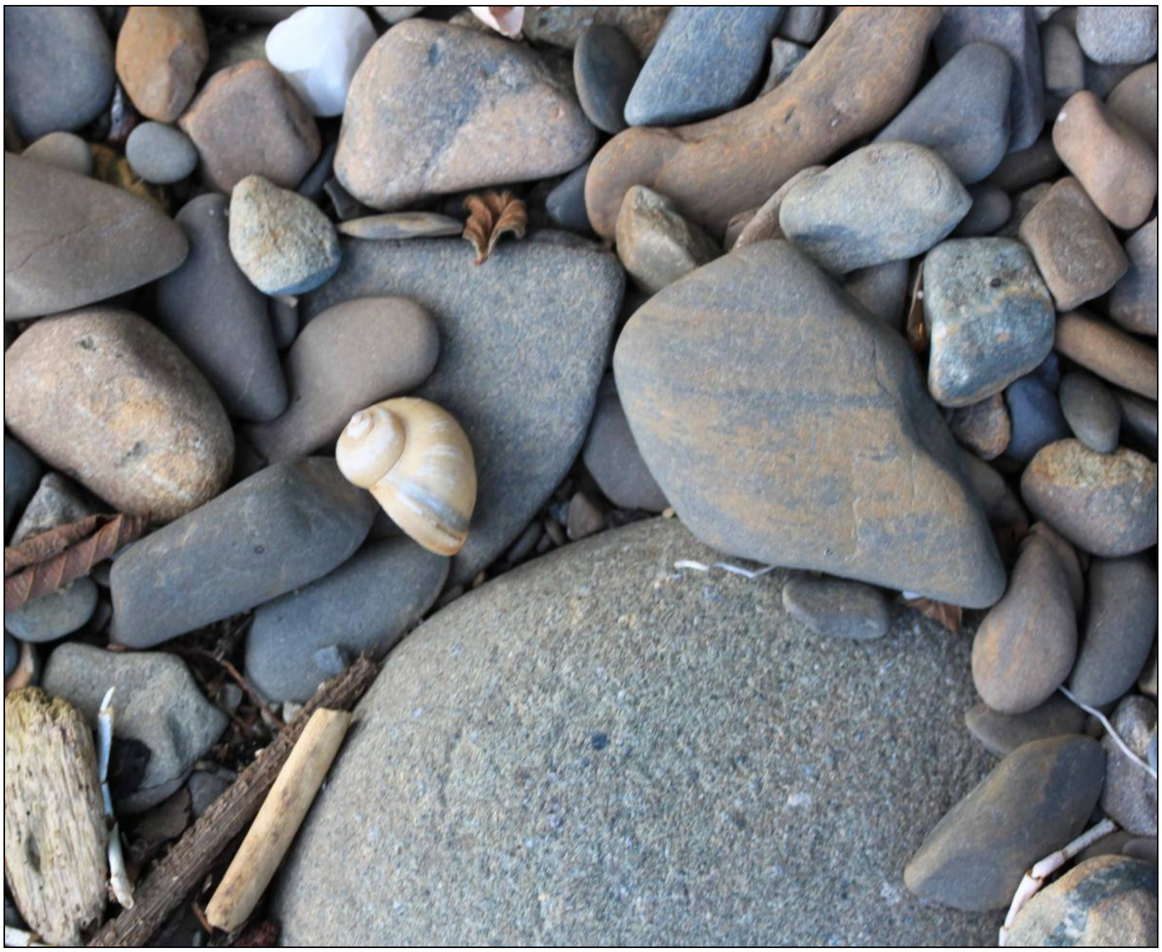
Freshwater Snail Inventory of the Fish River Lakes

2/2012

Report for MOHF Agreement Number CT09A 2011 0605 6177



by Kenneth P. Hotopp
Appalachian Conservation Biology
PO Box 1298, Bethel, ME 04217

for the Maine Outdoor Heritage Fund
37 Wiscasset Rd.
Pittston, ME 04345

Freshwater Snail Inventory of the Fish River Lakes

Abstract

Freshwater snails were inventoried at the eight major lakes of the Fish River watershed, Aroostook County, Maine, with special attention toward pond snails (Lymnaeidae) collected historically by regional naturalist Olof Nylander. A total of fourteen freshwater snail species in six families were recovered. The pond snail *Stagnicola emarginatus* (Say, 1821) was found at Square Lake, Eagle Lake, and Fish River Lake, with different populations exhibiting regional shell forms as observed by Nylander, but not found in three other lakes previously reported. More intensive inventory is necessary for confirmation. The occurrence of transitional shell forms, and authoritative literature, do not support the elevation of the endemic species *Stagnicola mighelsi* (W.G. Binney, 1865). However, the infrequent occurrence of *S. emarginatus* in all of its forms, and potential threats to this species, warrant a statewide assessment of its habitat and conservation status. Otherwise, a qualitative comparison with the Fish River Lakes freshwater snail fauna of 100 years ago suggests it remains mostly intact today.

Contents

Field collecting on Long Lake; Marian R. Hotopp, Trenton V. Bonney, and Judith Roe, PhD. KPH

Introduction

Freshwater snails live in all of our North American lakes, streams, and wetlands. They are generally small animals only a few millimeters long, with a hard calcium carbonate shell containing a soft body. The shell has an opening that allows the animal to extend its head and foot, for crawling about and eating. They are usually found on underwater rock, mud, sand, plants, or debris, with some species found in stagnant water, shallows, damp shoreline, and even nearby forest. Freshwater snails are mainly herbivores and detritivores, grazing upon particles suspended in the water column, bacteria, diatoms, algae and plants, though a few will eat dead animals (*in* Burch, 1988; Dillon, 2000; 2006). They are, in turn, prey for a wide variety of aquatic invertebrates, fish, amphibians and reptiles, and waterfowl.

There are at least 38 freshwater snail species in seven families reported for Maine (Martin, 1999). The primary taxonomic division is between those with gills, called Prosobranchs, and those with lungs, called Pulmonates. Snail taxonomic families are either one or the other, and the lymnaeids of special interest here are Pulmonates.

Freshwater snails employ a variety of reproductive strategies across the taxon. Prosobranchs are male or female, while Pulmonates are hermaphroditic, though usually playing only a male or female role in a given mating (*in* Dillon, 2000). Many freshwater snail species can store sperm, some can self-fertilize, and a few of the Prosobranchs can even reproduce by parthenogenesis. Eggs may be laid in the environment or develop within the adult before "birth."

Environmental variables such as water temperature, dissolved oxygen, and calcium are important determinants of snail community species composition (*in* Dillon, 2000). The size of lakes or river systems is also an important correlate, related to habitat complexity, food availability, and water chemistry. Snails sometimes play important ecological roles in cycling energy and nutrients within aquatic systems. Freshwater snails are parasite hosts as well, for organisms such as swimmer's itch (*Schistosoma* spp.) and flukes (*Fasciola* spp.) that spend part of their life cycle in warm-blooded animals including livestock or people. Freshwater snails vary in their tolerance of changes in water bodies, including anthropogenic impacts from water pollution such as agricultural or urban runoff; to water quality degradation such as that from acid rain; and to habitat loss from sedimentation, dredging, or dams.

Olof Nylander (1864-1943) immigrated to the United States from Sweden in 1880 (Martin, 1995). Eventually settling near Caribou, Maine, to be near his brother, he farmed and raised a family but spent much of his free time collecting fossils, shells, and plants. He collected widely in northern Maine and adjacent Canada, often accompanied by other family members. His work in the Fish River Lakes was conducted mostly between 1896 and 1928. Nylander became internationally recognized for his contributions to science, and in 1939 the town of Caribou dedicated a WPA-built museum for his collections, where he was the first curator.

Olof Nylander circa 1922, courtesy Nylander Museum.

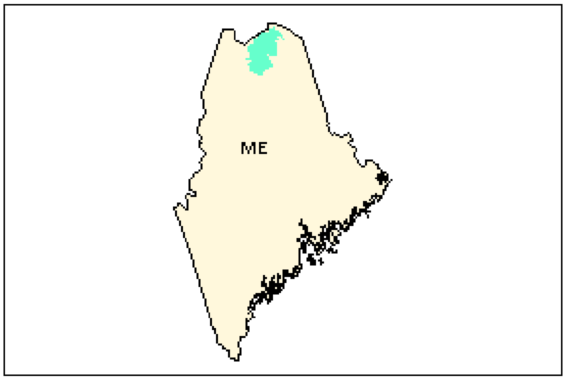


Figure 1. Location of the Fish River Lakes watershed, from US EPA (2012).

Study Area

The Fish River watershed is a complex of rivers and lakes in north-central Aroostook County, Maine (Figures 1, 2). The watershed is 2,311 km^2 (571,073 acres) in size (US EPA, 2012), with eight major lakes and many smaller lakes and ponds. Of the eight large lakes, Square is the largest, at 3,298 ha (8,150 acres; Table 1). Larger lakes in this watershed are naturally-occurring, not created or maintained by dams. The central Fish River drains this watershed to the north, entering the St. Johns River at Fort Kent, and from there flowing southeast to the Atlantic.

Bedrock geology of the Fish River watershed is dominated by undifferentiated lower Devonian, undifferentiated Silurian, and Ordovician sedimentary rocks (Roy, 1987). Physiography is moderate, with relief mostly between 183m-366m (600’-1,200’). The climate data from Eagle Lake shows the warmest month is July, with an average maximum temperature of 24.4°C (76°F) and February is the coldest month with an average minimum temperature of -23°C (-10°F). Average annual precipitation at Eagle Lake is 99cm (39”) and average annual snowfall is 455cm (179”). The 40-year trend in ice-out dates at Eagle Lake is 3-3.5 days earlier each decade (New England Integrated Sciences & Assessment, 2012).

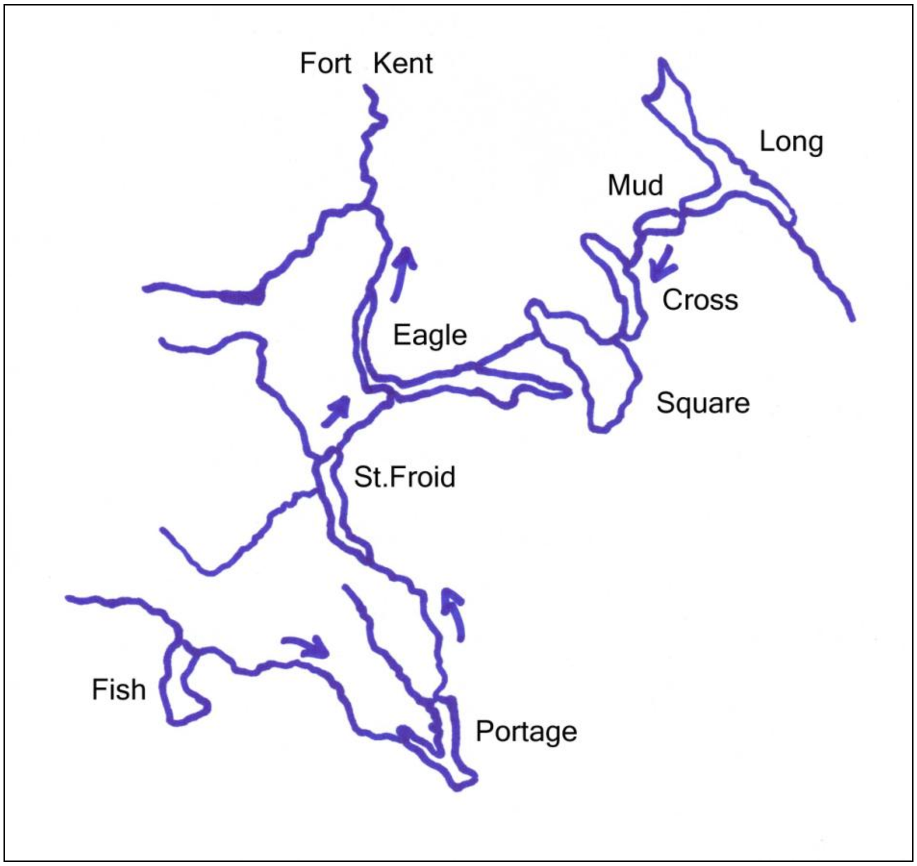


Figure 2. Eight major lakes of the Fish River watershed inventoried for freshwater snails. Arrows indicate direction of water flow.

The Fish River watershed falls along the western boundary of the Aroostook Hills and Lowlands Ecoregion, which has 46 different natural community types (*in* Gawler and Cutko, 2010). Upland forests are mostly northern hardwood, spruce and fir types, and forested wetlands range from acidic black spruce to richer northern white cedar fens. Floodplain forests are balsam poplar or silver maple types. Open wetlands, lakeshores and rivershores vary widely.

Table 1. Sizes of the eight largest Fish River Lakes, from east to west (MDIF&W, 2012).

lake	hectares	acres
Long	2,428	6,000
Mud	407	1,006
Cross	1,018	2,515
Square	3,298	8,150
Eagle	2,259	5,581
St. Froid	971	2,400
Portage	1,001	2,474
Fish River	1,069	2,642

Extensive bulrush stand at Mud Lake inlet. KPH

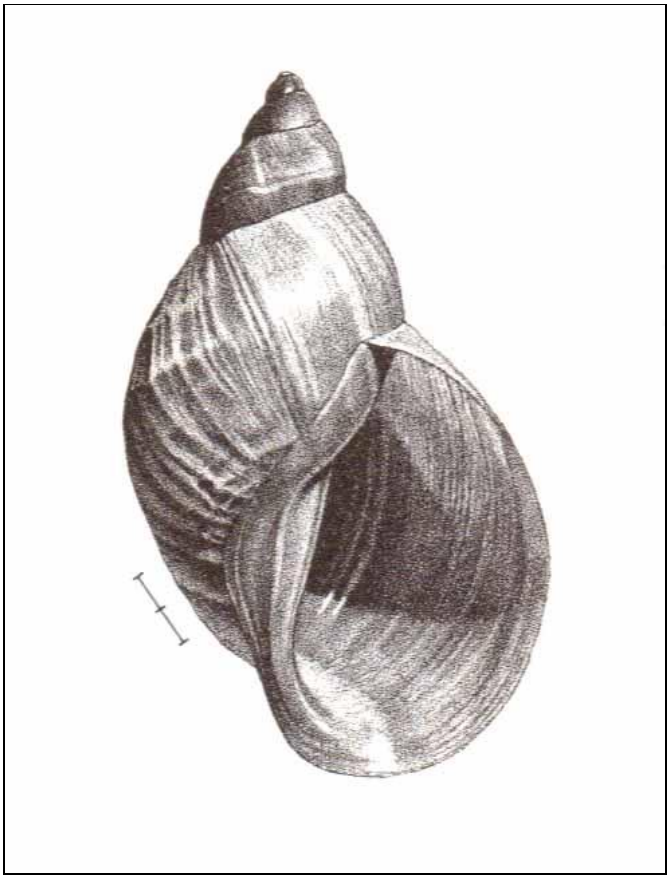


Figure 3. *Stagnicola emarginatus* (Say, 1858) from Burch & Tottenham, 1980. Scale line 2mm.

Focus Animals

Pond snails of the genus *Stagnicola* were of particular interest to Nylander, and to us, because of their patchy distribution, large size, and unique shell shapes. *Stagnicola emarginatus* (Say, 1858) is a large snail, from 18.5-30mm, with approximately 5 whorls (Baker, 1911; Figures 3, 4). Its shell is variable:

> …convex to subglobose, shouldered, more or less inflated, the last whorl large and usually quite convex, showing a tendency to expand and flare, and also to become shouldered; spire varying from broadly, acutely pyramidal, to depressed,

> globose, or flattened, frequently eroded; sutures generally deeply impressed in some individuals markedly so; aperture ovate or somewhat rectangular, very large, somewhat expanded or flaring in some specimens, a trifle effuse anteriorly; the aperture occupying one-half to two-thirds of the shell…

The inside of the aperture is white, and the outside protein coat (periostracum) glossy or matte, whitish or tan, often yellowish or greenish-brown, to dark brown. The animal itself has very dark, bluish-black skin, flecked with very fine white speckles. It has a wide foot and a short head with two tentacles. Its internal anatomy includes a penis approximately 2mm, vas deferens approximately 24mm, prostatic duct 6mm, and seminal receptacle 6mm.

Figure 4. *Stagnicola emarginatus mighelsi* exhibiting the flared aperture, strongly shouldered whorls, and blunt apex typical of this form. KPH

This snail ranges from Maine and northern New York to western Ontario and northern Michigan. Its habitat is usually gravelly or stony lakeshore bottom in shallow water up to a meter deep (Nylander, 1942; Gleason *in* Baker, 1911), where it grazes upon the "confervae," or green algae, growing on rocks. Baker recognizes five "races," including *Stagnicola emarginatus mighelsi* (W.G. Binney, 1903), each representing a geographic form found in different parts of the species' range.

Baker (1911) characterizes *S. e. mighelsi* as sometimes having a reduced spire, and a final whorl that is "very large, flaring, and strongly shouldered." The shell may have ridges at growth interruptions in the final whorl, and whitish or reddish spiral streaks. Its internal anatomy is like that of *S. emarginatus*. This form occurs in northern Maine and nearby southeastern Canada. This animal has been treated as a subspecies, race, or form, by some authors (Baker, 1911; Nylander, 1942; Hubendick, 1951), as a full species by others (Burch, 1988; Turgeon et al., 1998; Martin 1999; NatureServe, 2011), and is not addressed by Clarke (1981).

Methods

A freshwater snail inventory was planned for the Fish River lakes, collected a century ago by Caribou, Maine, naturalist Olof Nylander (1914, 1921, 1936, 1942). Using topographic maps and aerial photographs, the shorelines of bays, deltas, inlets, and outlets, especially with sparse aquatic emergent vegetation, were targeted for searches. Sand and cobble beaches, and rock outcrops, were also checked. Specific locales reported by Nylander were revisited at Cross Lake, Square Lake, Portage Lake, and Fish River Lake.

Field work to collect both living snails and empty shells was conducted along the shoreline of lakes by teams of two to four people, on foot and by canoe and kayak. Large areas of mud, cobble, and sand substrate were checked visually, by walking or boating in shallow water along the shore. The stems and leaves of aquatic plants were frequently checked - by visual inspection and by running fingers over their surfaces - as well as submerged rocks, stumps and logs. The wrack line along beaches was also searched for shells, often by pulling apart accumulated plant debris. Mud bottoms, especially in water deeper than one meter, was sporadically checked by shallow dredging with a "D net." Fast running streams entering lakes were only casually searched, and lake bottom deeper than approximately two meters was not checked. Both empty shells and live snails were collected and placed in polystyrene vials.

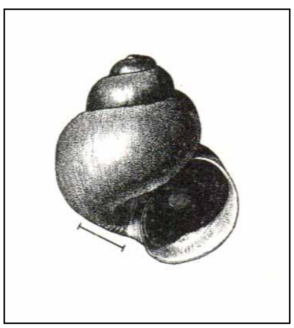
Field notes were written characterizing the substrate and habitat, and Global Positioning System (GPS) coordinates were recorded for each collection site. We measured pH colorimetrically with a Cornell test kit. In the laboratory, empty shells were dried, and live animals were anaesthetized in water with menthol crystals for 24 hours, after which they were placed in 70% ethanol. Identification was conducted with the aid of a dissecting microscope and reference works by Clarke (1981), Jokinen (1992), and Martin (1999).


Handful of freshwater snail shells including *S. e. mighelsi* from the Square Lake inlet. KPH

Results

Freshwater snails were inventoried at 18 collection sites at eight major lakes in the Fish River watershed (Figure 5, Table 2). These sites varied in size, with the largest (Three Brooks Cove, Eagle Lake; Oak Point, Portage Lake) covering more than a kilometer of shoreline, and the smallest (lakeshore on Long Lake's north end), approximately 500 m^2. A total of fourteen freshwater snail species in six families were found at these sites (Table 3, Appendix 1), with more than 500 specimens collected.

The most frequently collected snail species was *Amnicola* cf *limosa* (Say, 1817), found at all eight lakes. This tiny hydrobiid was found upon submerged aquatic vegetation (SAV) and reached very high numbers, probably thousands per square meter, in a deep, darkwater tributary of Mud Lake. *Helisoma anceps* (Menke, 1830), *Planorbella campanulata* (Say, 1821), and *Planorbella trivolvis* (Say, 1817) were each found at six lakes; and *Physa ancillaria* (Say, 1825) and *Gyraulus deflectus* (Say, 1824) at five lakes. The least common species were two lymnaeids *Fossaria* cf *modicella* (Say, 1825) and *F.* cf *obrussa* (Say, 1825), each represented by only a single specimen, and the planorbid *Promenetus exacuous* (Say, 1821), found at only one site. A small stagnant bay with aquatic emergents such as cattails near the Long Lake boat launch was the collection site for *F. modicella* and *P. exacuous*. A small darkwater tributary at St. Froid Lake, with aquatic emergents including pickerelweed, was the site where *F. obrussa* was found.



Amnicola limosa from Burch & Tottenham, 1980. Scale bar 1mm

Figure 5. Google Earth image of freshwater snail inventory sites in the Fish River Lakes. *Stagnicola emarginatus* sites are in yellow, all others are red. North is to the lower right.

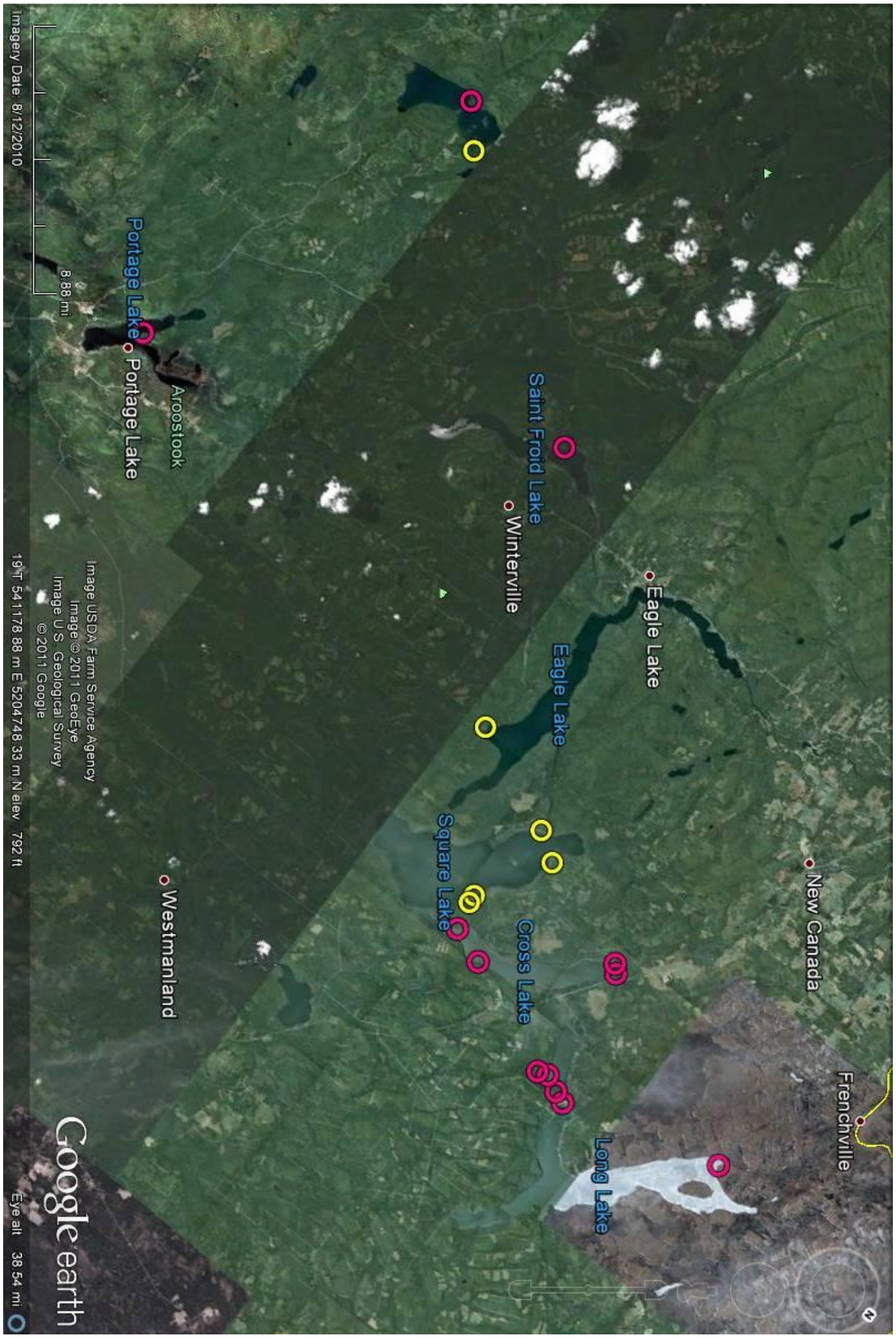


Table 2. Freshwater snail collection site characteristics (UTM zone 19T, base datum NAD83). Sites are ordered by approximate geographic location from east to west.

locale/site	coord's	habitat
Long Lake 8/4/11#3 launch	0555501 5223894	stone and sand beach, nearby stagnant cattail wetland; pH 7.2
Long Lake 8/4/11#4	0552946 5232519	stone, sand, mud, with rushes, phragmites; pH 7.0
Mud Lake 8/5/11#1 rush	0555248 5223237	large rush stand on sand; pH 6.9
Mud Lake 8/5/11#2 midden	0554819 5222346	mostly stony also sandy shallows at shrub and forest shore, with freshwater mussels
Mud Lake 8/5/11#3 trib	0555008 5221789	slow darkwater tributary with dense SAV; pH 6.8
Cross Lake 8/3/11#1	0552382 5215655	boat launch beach, gravely with few plants
Cross Lake 8/3/11#4 beaver	0551686 5213698	sand beach with alders and beaver meadow behind
Cross Lake 8/4/11#1 N end	0547909 5221481	tributary mouth with mainly sand bottom and rushes; pH 7-7.2
Cross Lake 8/4/11#2 N end	0548296 5221847	large trib delta with rushes and SAV on sand at trib mouth
Square Lake 8/3/11#2 inlet	0550173 5213323	mud and sand islands and shore at mouth of inlet, sedges, rushes, dense emergent stands; pH 7-7.2
Square Lake 8/3/11#3 gravel spit	0549727 5213297	small cove with emergents, rushes, alders at shore, sand and gravel spit
Square Lake 8/5/11#4 burnt lndg	0545757 5215480	stony bottom with some sand and small rush stand, high-energy lakeshore; pH 7.2
Square Lake 8/5/11#5 t'fare	0544764 5213954	stony outlet, with snails in small cove with some sand and fine mud as well; pH 7.1
Eagle Lake 8/6/11#1 3 brooks	0542284 5208189	large cove with trib mouths, mainly sandy with some mud and stone substrate, wrack; pH 7.2
St. Froid Lake 8/7/11#1	0527929 5202226	mostly sand, with wrack, but mud at darkwater tributary mouth; pH 6.8
Portage Lake 8/8/11#2 oak pt	0537124 5180744	stony and sandy bottom, sparse rushes, high-energy beach; pH 7.2
Fish River Lake 8/7/11#2 delta	0516474 5186809	very cold tributary mouth with sand, stone and mud substrates, various emergents; pH 6.7
Fish River Lake 8/8/11#1 outlet	0518457 5188578	mostly stony bottom in very clear water

Table 3. Freshwater snails collected in the Fish River drainage in 2011.

Viviparidae	
Campeloma decisum (Say, 1817)	
Hydrobiidae	
Amnicola cf *limosa* (Say, 1817)	
Lymnaeidae	
Fossaria cf *modicella* (Say, 1825)	
Fossaria cf *obrussa* (Say, 1825)	
Stagnicola cf *emarginatus* (Say, 1821)*	
* includes *S.e. mighelsi* (W.G. Binney, 1865)	
Physidae	
Physa ancillaria (Say, 1825)	
Physa gyrina (Say, 1821)	
Planorbidae	
Gyraulus deflectus (Say, 1824)	
Gyraulus parvus (Say, 1821)	
Helisoma anceps (Menke, 1830)	
Planorbella campanulata (Say, 1821)	
Planorbella trivolvis (Say, 1817)	
Promenetus exacuous (Say, 1821)	
Ancylidae	
Ferrissia cf *californica (fragilis)* (Rowell, 1863)	

A qualitative comparison of our results with that of Nylander (1936, 1942) indicates apparent changes in the distribution of four freshwater snails. Looking first at the Lymnaeidae, which received particular attention from Nylander, the pond snail *Stagnicola* cf *emarginatus* (Say, 1821) was found at three of the lakes - Square Lake, Eagle Lake, and Fish River Lake (Table 4). Different populations exhibited local shell forms, as observed by Nylander and reported by him as *S. emarginatus* or *S. e. mighelsi* (e.g. Figure 4). *Stagnicola emarginatus* was not relocated in three other lakes where it was found previously by Nylander – Mud Lake, Cross Lake, and Portage Lake. At Square Lake and Fish River Lake we recovered specimens at the exact locations where Nylander had found them, while the site at Eagle Lake, and at least one site at Square Lake, are new. At Mud Lake we collected in three different habitats but did not find the species. At Cross Lake, although we searched extensively and did not find *S. emarginatus*, we did not inventory the exact locations where Nylander had found the species at the inlet and at Cranberry Point. At Portage Lake we thoroughly searched Oak Point where Nylander had found *S. emarginatus* in the past, without success.

Table 4. Presence of *Stagnicola emarginatus* at Fish River Lakes.

lake	Nylander	current
Long		
Mud	√	
Cross	√	
Square	√	√
Eagle	√	√
St. Froid		
Portage	√	
Fish	√	√

What follows is a comparison between the lake distributions of freshwater snail species we encountered and those of Nylander's (1936, 1942), by family.

Valvatidae

No animals from this family were found. Nylander reports *Valvata sincera* Say, 1824 (form *nylanderi* Dall) from deep water (5m+) in Portage Lake, and also Eagle and Square Lakes.

Viviparidae

Campeloma decisum was found in this project at Cross, Square, Eagle, and Portage Lakes. Nylander (1936) reports this species for the "Fish River Lakes."

Hydrobiidae

Amnicola cf *limosa* was found at every lake in this study. Nylander (1936) also reports it "in every lake I have explored."

Lymnaeidae

We encountered *S. emarginatus* at Square, Portage and Fish River Lakes, as stated above. Nylander found forms of this animal at these same lakes, but also Mud, Cross, and Portage. We found *Fossaria* cf *obrussa* at St. Froid Lake and *F*. cf *modicella* at Long Lake. Nylander reported *F. obrussa* to be "quite common in many of our lakes and streams," but did not report *F. modicella*.

Physidae

We found *Physa ancillaria* (Say, 1825) at Long, Mud, Cross, Eagle, and Portage Lakes. Nylander too reports this species at Portage and Mud Lakes, but also from the Square Lake inlet (1936). We found the larger species *Physa gyrina* (Say, 1821) at Fish River Lake. It is not reported by Nylander.

Planorbidae

We found six species in this family, with *Helisoma anceps* (Menke, 1830), *Planorbella campanulata* (Say, 1821), and the large *Planorbella trivolvis* (Say, 1817) being widespread. Nylander found the same wide distribution for these species, though *H. anceps* was reported as *Planorbis antrosus* Conrad. Nylander found *P. antrosus* in "most every body of running water in the state," and also reports a unique form *Planorbis antrosus portagensis* Baker from Portage Lake.

We found *Gyraulus deflectus* (Say, 1824) at five lakes, including Portage Lake, but Nylander (1936) called this a "rare shell" and in the Fish River watershed recovered it only in northwest Portage Lake. Conversely, we found *Gyraulus parvus* (Say, 1821) only at Eagle and St. Froid Lakes, whereas Nylander (1936) found it to be "…one of the most common of the small shells in lakes and streams…"

Promenetus exacuous (Say, 1821) was encountered in this project only at a wetland on Long Lake. Nylander reported this species from only Square Lake inlet and Portage Lake.

Ancylidae

Ferrissia cf *californica (fragilis)* (Rowell, 1863) was widespread, and particularly abundant in some rush stands. Nylander (1936), however, reports *Ancylus parallelus* Haldeman, a synonym, only from Cross Lake in this watershed.

Here we characterize the collection sites and highlight findings at each lake, from east to west - downstream on the East Branch of the Fish River from Long Lake to Eagle Lake, and then upstream on the West Branch of the Fish River from Eagle Lake to Fish River Lake.

Figure 6. Long Lake boat launch.

Long Lake

This is the easternmost of the lakes, and unlike the other lakes has significant development and agricultural fields in its vicinity. Collections were made in two places at Long Lake: at the gravel beach around the boat launch (Figures 6, 7) and shoreline, including a small stagnant cove, on the south end of the lake; and at a mud bar and associated emergent wetland on the north end (Figure 8). The boat launch site, in particular the swampy cove, yielded seven species of freshwater snails, including two species collected nowhere else – *Fossaria* cf *modicella* (say, 1825) and *Promenetus exacuous* (Say, 1821) (Figures 9, 10). Both sites were highly disturbed, with a gravel parking area, mowed vegetation, and cattails in the associated cove at the south end, and with phragmites at the north end, which also held the non-native land snail *Succinea putris* (Linnaeus, 1758) on its stems.

Figure 7. The yellow line indicates the search area at the boat launch on the south end of Long Lake. Aerial photograph from Google Earth.

Figure 8. The yellow line indicates the approximate search area at the north end of Long Lake. Aerial photograph from Google Earth. The white area over most of the image is lake ice.

Figures 9, 10. Freshwater snails at Long Lake boat launch included *Fossaria* cf *modicella* (left; 5mm tall) and *Promenetus exacuous* above (right; 4mm diameter). KPH

Mud Lake

Just downstream of Long Lake, this shallow lake is surrounded by forest with some development on the west shore. Hectares of rush stands surround the inlet, and it is on these stems that large numbers of *Ferrissia* cf *californica* (Rowell, 1863) (until recently known as *F. fragilis*) and *Gyraulus deflectus* (Say, 1824) were encountered (Figures 11, 12, 13). Collections were also made in two locations on the east side, one in a small cove with a large midden of freshwater mussel shells (Figure 14). The second site on the east side was a slow-moving tributary reach below a large beaver dam. This area had dense submerged aquatic vegetation (SAV), heavily populated with *Amnicola* cf *limosa* (Figures 15, 16).

Figure 11. *Ferrissia* cf *californica* on a rush stem near the Mud Lake inlet.

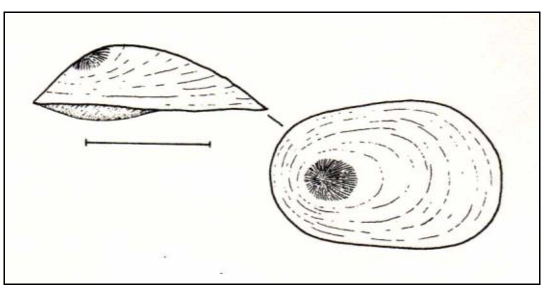


Figure 12. *Ferrissia* cf *californica* from Burch & Tottenham, 1980. Scale bar 1mm.

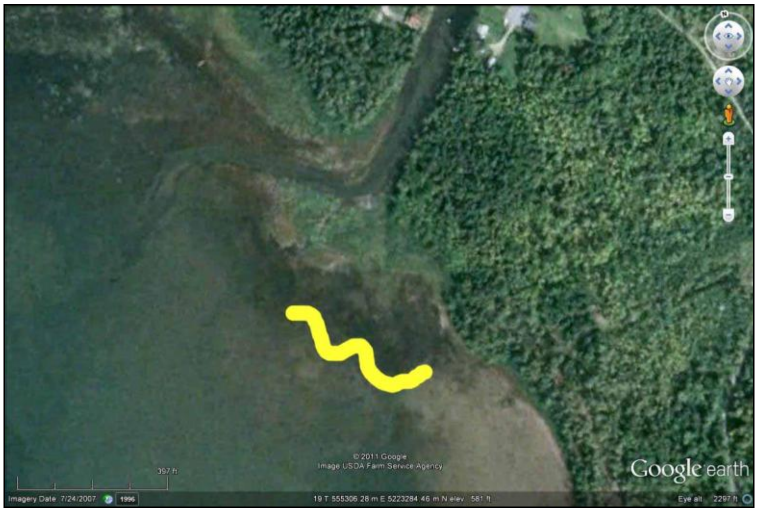


Figure 13. The yellow line indicates the approximate location of snail collections in an extensive rush stand near the Mud Lake inlet (top center). Aerial photograph from Google Earth.

Figure 14. The yellow line indicates the approximate search area at a small cove on the east shore of Mud Lake. Aerial photograph from Google Earth.

Figure 15. The yellow line indicates the approximate search area on a tributary on the east side of Mud Lake. Aerial photograph from Google Earth.

Figure 16. Mud Lake tributary reach where high densities of *Amnicola* cf *limosa* were found. KPH

Figure 17. Looking south from a tributary mouth bulrush stand at the north end of Cross Lake. KPH

Cross Lake

Four sites were collected at Cross Lake, which has camp development along parts of its shoreline. Two collections were at the mouths of tributaries at the north end of the lake, where sand and mud deltas provided extensive emergent wetlands (Figures 17, 18). The beach at the boat launch was somewhat disturbed and the shoreline lacked understory vegetation (Figure 19). The beach at the south end was collected as well as the small tributary in the beaver meadow behind the beach (Figures 20, 21). Eight freshwater snail species were found on this lake, but no lymnaeids.

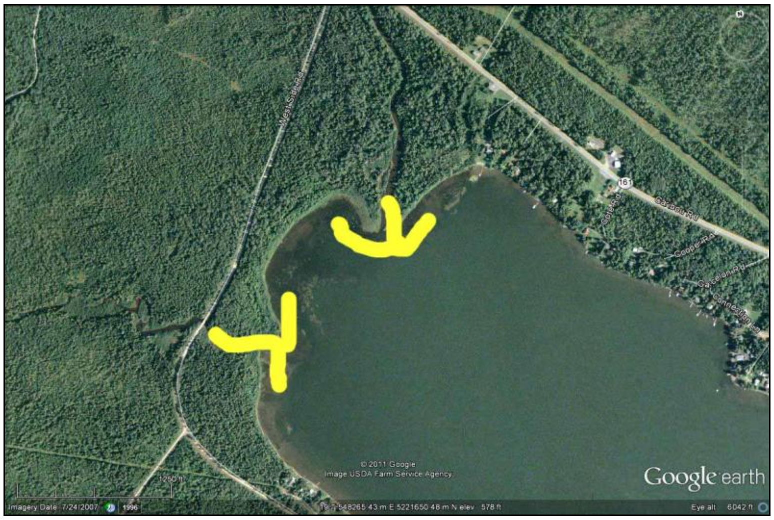


Figure 18. The yellow line indicates the approximate search area on two tributaries and their associated estuaries on the north end of Cross Lake. Aerial photograph from Google Earth.

Figure 19. The yellow line indicates the approximate search area on the gravel beach boat launch on the southeastern shore of Cross Lake. Aerial photograph from Google Earth.

Figure 20. The yellow line indicates the approximate search area on the sand beach and associated wetland tributary on the south end of Cross Lake. The outlet is to the left. Aerial photograph from Google Earth.

Figure 21. Abandoned beaver pond at the south end of Cross Lake. KPH

<u>Square Lake</u>

Four sites were searched at Square Lake, among the least developed of the Fish River Lakes. The first two were near the inlet from Cross Lake where Nylander determined that Longfellow had found *S. e. mighelsi* (Figures 22, 23). A small estuary is present at the inlet mouth, with transient islands, and a sand beach with an emergent wetland behind (inshore). We found many freshwater snail shells in this area, including the largest number of *Campeloma decisum* (Say, 1817) and *S. emarginatus* in this study. Several live individuals were found in only 1-2dm of standing water, on a sand, gravel, and mud bottom between horsetail (*Equisetum* sp.) stems in the wetland. A few more shells were found at a small cove to the west (Figure 23).

Figure 22. Small beach and cove at the type locality of *S .e. mighelsi* on the west side of the Square Lake inlet. KPH

Stagnicola emarginatus shells were also found on sand and cobble bottom at a cove near Burnt Landing (Figures 24, 25), and on a mixed mud, gravel, and sand bottom on the south side of the outlet thoroughfare to Eagle Lake (Figures 26, 27). The inlet and Burnt Landing sites both had some shells that were larger and had "shouldered" whorls, exhibiting the *S. e. mighelsi* form, while the *S. emarginatus* shells at the thoroughfare were more typical *S. emarginatus*.

Figure 23. The yellow line indicates the approximate search areas on the estuary at the Square Lake inlet and small cove nearby. Aerial photograph from Google Earth.

Figure 24. The yellow line indicates the approximate search area on the cobble and sand beach on the east side of Square Lake. Aerial photograph from Google Earth.

Figure 25. Cobble lakeshore at *S. e. mighelsi* collection site near Burnt Landing, Square Lake. KPH

Figure 26. The yellow line indicates the approximate search area on either side of the outlet thoroughfare from Square Lake. Aerial photograph from Google Earth.

Figure 27. *Stagnicola emarginatus* from the south side of the Square Lake outlet thoroughfare. KPH

Eagle Lake

An extensive search was conducted at Three Brooks Cove on Eagle Lake, examining sand beaches, lakeshore stands of shrubs and rushes, and a beaver meadow (Figure 28). Although the west end of Eagle Lake is extensively developed, this cove is several kilometers to the east with forested shoreline. Nine species of freshwater snails were found in the various habitats in this cove. Planorbid and *S. e. mighelsi* specimens were discovered at intervals along the beach, especially in the wrack line.

Figure 28. The yellow line indicates the approximate search area around the shoreline of Three Brooks Cove on Eagle Lake. Aerial photograph from Google Earth.

St. Froid Lake

The search location at St. Froid Lake was at the mouth of a tributary on the west side, with alder thickets and emergent wetland vegetation on a substrate of sand or mud (Figure 29). Snails were largely absent from shoreline beaches and wrack, and no *S. emarginatus* were found. However, SAV in the sheltered and slow-moving tributary mouth did hold freshwater snails, and this was where the sole specimen of *Fossaria* cf *obrussa* (Say, 1825) was found (Figures 30, 31).

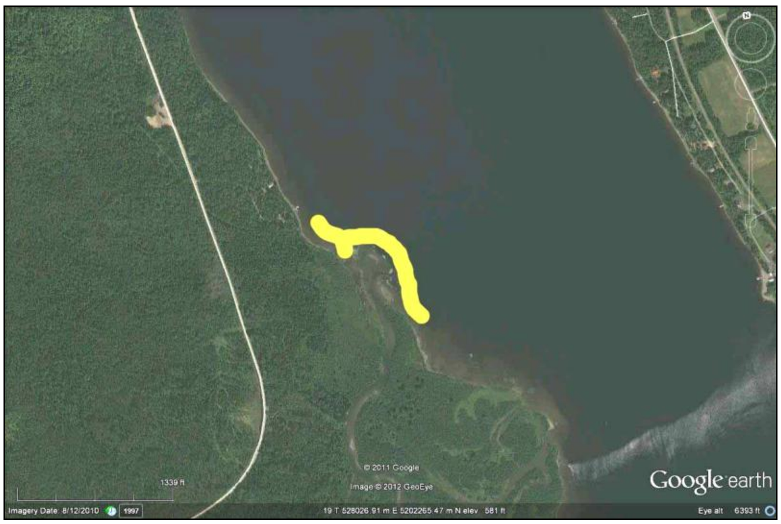


Figure 29. The yellow line indicates the approximate search area around the tributary mouth and west shoreline of St. Froid Lake. Aerial photograph from Google Earth.

Figures 30, 31. Pickerelweed at stream mouth, St. Froid Lake; *Fossaria* cf *obrussa* (1.9mm). KPH


View toward Oak Point from a boat launch on Portage Lake.

Portage Lake

Extensive areas of sand and cobble bottom were searched at Oak Point on Portage Lake (Figure 32), from which Nylander reported *S. e. mighelsi*. Many specimens of *H. anceps* and *P. campanulata* were observed, and *A.* cf *limosa* was on SAV close to shore. Oak Point has low-density development with small camps, while other parts of the shore are densely developed, and some adjacent wetland areas to the west and northwest are quite undisturbed.

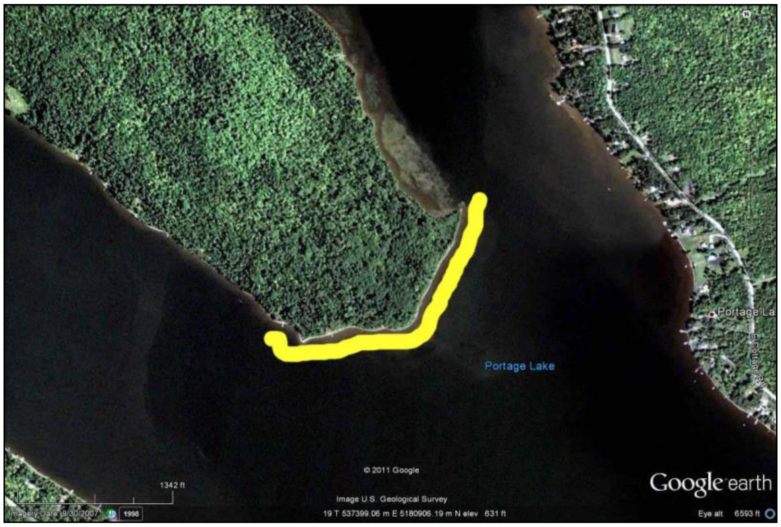


Figure 32. The yellow line indicates the approximate search area around Oak Point on Portage Lake. Aerial photograph from Google Earth.

Fish River Lake

This is the most remote of the Fish River lakes, though it is still surrounded by commercial logging, logging roads, and there are a few camps on the lake. We collected snails in two places, at a tributary mouth on the west side, and shoreline of the north end, where Nylander had collected previously (Figures 34, 35). Freshwater snails except *P. campanulata* (Figure 33) were generally at low densities, although a total of seven species were encountered.

Figure 33. *Planorbella campanulata* shell. KPH

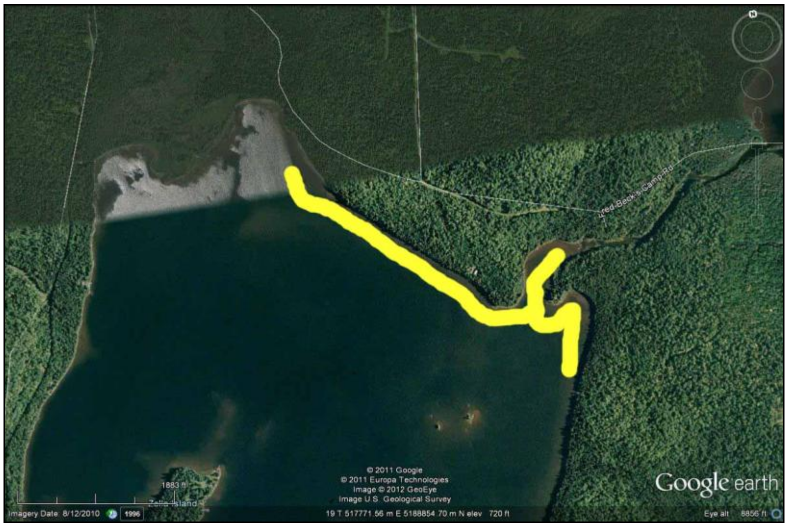


Figure 34. The yellow line indicates the approximate search area at the north shore and outlet of Fish River Lake outlet. Aerial photograph from Google Earth.

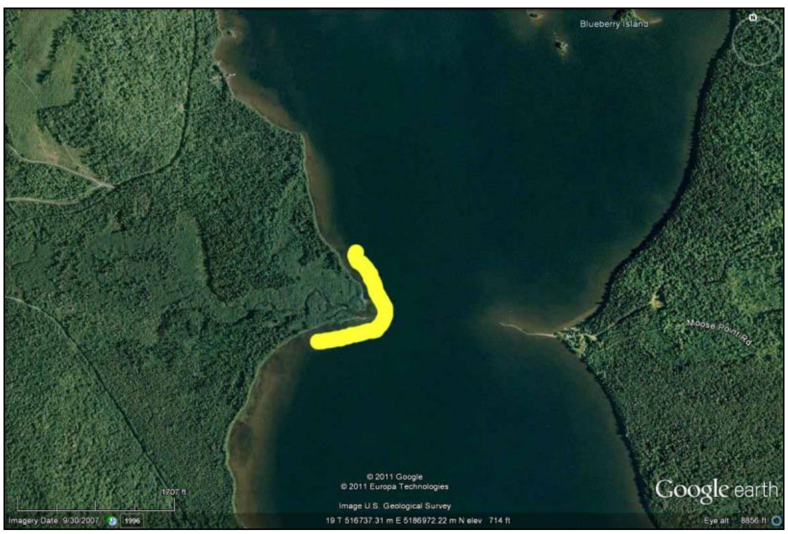


Figure 35. The yellow line indicates the approximate search area at the tributary mouth on the west shore of Fish River Lake. Aerial photograph from Google Earth.

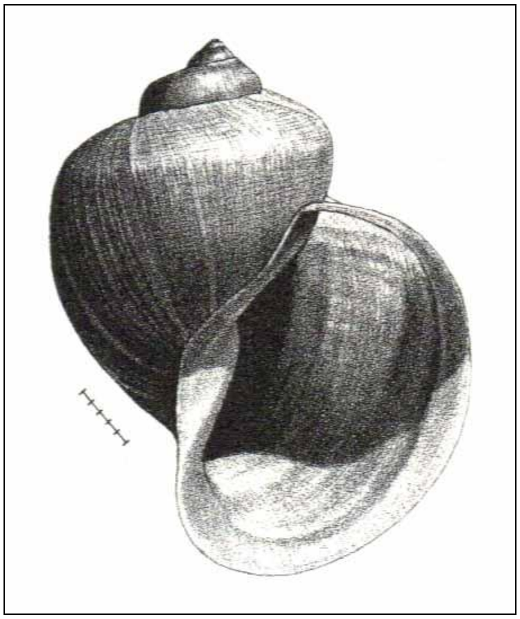


Figure 36. *Stagnicola emarginatus mighelsi* from Burch & Tottenham, 1980. Scale line 5mm.

Discussion

The freshwater snail fauna of the Fish River Lakes appears to be a widespread and important part of the watershed's aquatic systems, with small and large species present at all collecting sites. Beds of aquatic vegetation, emergent or submerged, sometimes harbor huge populations of small snails, with apparently millions of individuals, such as among the rush stands and tributary reaches of Mud Lake.

The pond snail *Stagnicola emarginatus* (Say, 1821) (Figure 36) was found at three of the lakes - Square Lake, Eagle Lake, and Fish River Lake – with different populations exhibiting local shell forms, as observed by Nylander (e.g. 1942). The distribution of shell shapes suggest that *Stagnicola mighelsi* (W.G. Binney, 1865), which has a large shell, flared aperture and shouldered whorls, is not a distinct species. Some *Stagnicola* species populations had many individuals that were typical *mighelsi* in shape, such as at the Square Lake inlet. There were sometimes other shells at the same sites with more conservative features, and in other places entire populations, such as at the Square Lake thoroughfare, which were smaller and more oval. We did not find a population that had two distinct *Stagnicola* forms without intermediaries, a pattern that would have suggested distinct species.

Baker (1911) considered *S. e. mighelsi* a "variety" and a "form" of *S. emarginatus*, and noted the "perfect" gradation of shell shapes between the two (noting that the bulk of specimens he examined were from Mud Lake, where we did not find any of these animals; though there may have been confusion over the lake names, as highlighted by Nylander, 1921). Baker also recognized the "forms" *angulata*, *ontariensis*, *canadensis*, and *wisconsinensis*.

Nylander consistently reported *mighelsi* as a subspecies (e.g. 1942). Hubendick (1951) mapped larger Maine *Stagnicola* animals as form "*angulata*", and mapped "*mighelsi*" as an upper-Midwestern form. He assigned *angulata*, *mighelsi*, and *oronoensis* all as regional forms of *Stagnicola emarginatus*. *Stagnicola e. oronoensis* (Baker, 1904) is a smaller form of *Stagnicola emarginatus* from the Penobscot River and Pushaw Lake (e.g. Nylander, 1942; Figure 37).

Burch (1982) elevated *mighelsi* and *oronoensis* to species-level, without explanation. About the genus *Stagnicola* he stated, in general terms, "Because of the fundamental uncertainties of their taxonomy, it is not easy to decide upon a nomenclatural scheme…" Subsequent authors apparently followed Burch's use. Ultimately, the richness of *S. emarginatus* forms is poorly understood, and the genetic or environmental bases for this phenotypic plasticity are unknown.

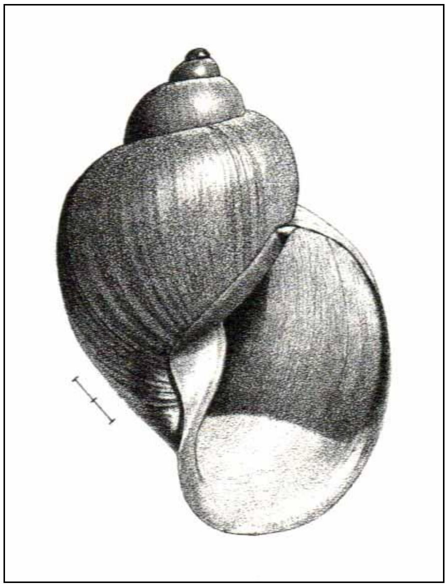


Figure 37. *Stagnicola emarginatus oronoensis* from Burch & Tottenham, 1980. Scale line 2mm.

Three inventoried lakes from which *Stagnicola* species snails were previously reported by Nylander did not yield specimens in this study – Mud Lake, Cross Lake, and Portage Lake. Hopefully these animals were merely overlooked. All of these lakes are large and a more extensive inventory would be necessary to confirm or refute the absence of these snails. Of particular concern is Mud Lake, which is the type locality for *S. emarginatus* (Nylander, 1914). Because such type localities are the source of specimens used for the original description of a given species, they are vital to our taxonomic understanding and research. In the case of *S. emarginatus*, the original type locality was not specified by Say, but was determined later by Nylander (1921) based upon his extensive collecting in northern Maine and nearby Canada.

A closer look at *S. emarginatus*, in all of its forms (including *S. e. mighelsi, S. e. oronoensis*) suggests that it is not common in Maine (Table 5). It is reported only from 16 locations, and the Sebago Lake report seems to be an unlikely outlier. Most populations are restricted to certain sections of shoreline, and certain water depths, and are never ubiquitous in a given body of water. There is a high degree of uncertainty about the size and extent of *S. emarginatus* populations, but at present there are perhaps only a few dozen hectares of habitat known for the state.

Table 5. *Stagnicola emarginatus* locations in Maine, including *S. e. mighelsi*, and *S. e. oronoensis,* from Baker (1911), Nylander (1914, 1942), and this report.

water body	last reported
Mud Lake (*emarginatus*)	1924*
Cross Lake (*emarginatus*, *mighelsi*)	1914*
Square Lake (*emarginatus*, *mighelsi*)	2011*
Eagle Lake (*emarginatus*, *mighelsi*)	2011*
Fish River above Eagle Lake (*emarginatus*)	1896
Portage Lake (*mighelsi*)	1898*
Fish River Lake (*emarginatus*, *mighelsi*)	2011*
Fish River at Ft. Kent (*emarginatus*)	1899
St. John River above Fish River (*emarginatus*)	1899
Big Brassua Lake (*mighelsi*)	1914
Aroostook R. above Caribou Stream (*oronoensis*)	1939
Penobscot River at Orono (*oronoensis*)	1941
Penobscot tributary at Orono (*oronoensis*)	1941
Pushaw Pond (*oronoensis*)	1941
Allagash Lake (*mighelsi*)	2009
Sebago Lake (*mighelsi*)	before 1911

*visited this report

Elsewhere in Maine, the big lakes in the upper Androscoggin River of western Maine – Rangeley, Mooselookmeguntic, Aziscohos, Richardson, and Umbagog – do not appear to hold *Stagnicola emarginatus* (Nylander, 1942; Hotopp, unpublished data). Nor do various other large lakes statewide where the author has informally checked beaches and coves in recent years – Chamberlain on the Allagash; Lobster Lake and Chesuncook Lake on the West Branch of the Penobscot River; or Grand Lake Matagamon on the East Branch of the Penobscot – though much potential habitat on these lakes remains, so this work has been far from exhaustive. One of the author's daughters, Alice M. Hotopp, found *S. e. mighelsi* shells on a beach at the north end of Allagash Lake in 2009, a new locale that shows inventory is incomplete.

Threats to *Stagnicola emarginatus* populations are largely unknown, but this species may be vulnerable to flooding, water quality changes, or habitat disturbance. Nylander (1942) states that raising water level can destroy *Stagnicola* species populations by flooding, and he assumes that the Brassua Lake population is lost due to damming. At Cross Lake, Nylander (1914, 1942) reports the Cranberry Point and inlet *Stagnicola* populations were lost, with the lakeshore being developed by 1940. However, Nylander (1942) also cites the absence of *S. e. mighelsi* at the Square Lake inlet – present in 1890 and 1900, gone in 1914 and 1940 despite little noticeable difference in the habitat – where we found perhaps the healthiest population of this animal in 2011. In an earlier publication (Nylander, 1921) had attributed the snail's absence to the development of sporting camps near the inlet after 1900.

More generally, freshwater snail declines are related to increases in agriculture and development, for example, as shown for a study of 308 lakes in southern Manitoba (Pip, 2000). In the present study, those sites at which *S. emarginatus* has persisted are the most remote and least developed – Square Lake, Eagle Lake, and Fish River Lake. Of these, only Eagle Lake has intensive development, but Three Brooks Cove where we sampled is several kilometers upstream of those developed shorelines. Conversely, two of the lakes where *S. emarginatus* was not found are intensively developed – Cross Lake and Portage Lake. Mud Lake is the exception, with only low-density development along its west shore. However, Mud Lake is the smallest and shallowest lake we sampled, and is immediately downstream of Long Lake, which has the most development and farming in the lake system. If further investigation confirms the absence of *S. emarginatus* from these three lakes, that absence may be related to anthropogenic impacts. Water quality changes would seem to be a potential cause, noting that these lakes have not been dammed since Nylander's time, and that there are no obvious impacts from excavation or shoreline erosion.

Table 6. pH and possible community-type assignments for sample sites.

locale/site *S. emarginatus* bold	pH's *	Total P** in ppb	possible community(s) e.g. Gawler & Cutko
Long Lake 8/4/11#3 launch	7.2 7.9 (2006)	14 (2006)	cattail marsh; lakeshore beach
Long Lake 8/4/11#4	7.0 7.9 (2006)	14 (2006)	bulrush marsh; sandy lake bottom, lakeshore beach
Mud Lake 8/5/11#1 rush	6.9 7.4 (1987)	11 (2003)	bulrush marsh
Mud Lake 8/5/11#2 midden	- 7.4 (1987)	11 (2003)	lakeshore beach; sandy lake-bottom
Mud Lake 8/5/11#3 trib	6.8 7.4 (1987)	11 (2003)	open-water marsh
Cross Lake 8/3/11#1	- 7.7 (2005)	13 (2005)	lakeshore beach
Cross Lake 8/3/11#4 beaver	- 7.7 (2005)	13 (2005)	lakeshore beach; alder thicket; sedge meadow; sandy lake-bottom
Cross Lake 8/4/11#1 N end	7-7.2 7.7 (2005)	13 (2005)	bulrush marsh, open-water marsh; sandy lake-bottom
Cross Lake 8/4/11#2 N end	- 7.7 (2005)	13 (2005)	bulrush marsh, open-water marsh; sandy lake-bottom
Square Lake **8/3/11#2 inlet**	7-7.2 7 (2008)	6 (2005)	bulrush marsh, sedge meadow, lakeshore beach; sandy lake bottom
Square Lake **8/3/11#3 gravel spit**	- 7 (2008)	6 (2005)	alder thicket; bulrush marsh; lakeshore beach
Square Lake **8/5/11#4 burnt lndg**	7.2 7 (2008)	6 (2005)	sandy lake-bottom; bulrush marsh; lakeshore beach
Square Lake **8/5/11#5 t'fare**	7.1 7 (2008)	6 (2005)	sandy lake-bottom; lakeshore beach
Eagle Lake **8/6/11#1 3 brooks**	7.2 7.6 (2001)	6 (2001)	lakeshore beach, sandy lake-bottom, bulrush marsh, alder thicket
St. Froid Lake 8/7/11#1	6.8 7.6 (1986)	6 (2002)	pickerelweed marsh, lakeshore beach, bulrush marsh, alder thicket
Portage Lake 8/8/11#2 oak pt	7.2 7.7 (2007)	9 (2002)	sandy lake-bottom, bulrush marsh; lakeshore beach
Fish River Lake 8/7/11#2 delta	6.7 7.6 (2001)	7 (2001)	bulrush marsh, sandy lakeshore; sandy lake-bottom; alder thicket; pickerelweed marsh
Fish River Lake **8/8/11#1 outlet**	- 7.6 (2001)	7 (2001)	sandy lake-bottom

* First pH at site colorimetrically; second pH most recent by Maine DEP, taken at lake center.
** Total P (phosphorous; ppb) by Maine DEP, taken at lake center.

With regard to water chemistry, we did not observe clear differences in pH correlated with the presence of *S. emarginatus* (Table 6), but of course there are a variety of other important water quality metrics. We did not test for the presence of pollutants such as nitrogen, phosphorous, pesticides, herbicides, etc. However, Maine Dept. of Environmental Protection made available their water quality monitoring information, which included pH and phosphorous among several metrics (R. Bouchard, 2001, pers. comm.). DEP pH readings taken at the center of lakes were consistently higher than those in this study taken at lakeshore collecting sites. Our colorimetric measurements were certainly less precise, and were often near tributary mouths or more influenced by groundwater influx. These influences would be expected to lower pH, while lake-center water has had more time in contact with biological processes and natural buffers. DEP phosphorous measurements show that nutrients are generally higher in the neighboring lakes Long, Mud, and Cross, than elsewhere, possibly related to farming on Long Lake. Although *S. emarginatus* appears to be absent in these three lakes, this nutrient by itself does not explain the overall pattern of *S. emarginatus* occurrence in the watershed. For example, Portage and St. Froid Lakes where the snail is absent also have relatively low P.

Community type assignments were attempted from observations of habitats at sample sites, based upon the classification system in Gawler and Cutko (2010; Table 6). Some community types were easily and frequently assigned, such as bulrush marsh and lakeshore beach. However, we often found extensive cobblestone beds at lakeshores and lake bottoms (e.g. Figure 25) that did not obviously fit into the classification system. These were assigned to sandy lake-bottom, in consideration of the sparse herbaceous vegetation in these cobble habitats.

Habitat for *S. emarginatus* generally conformed to that reported by other authors – cobble bottoms in shallow to deeper water, with varying degrees of sand or light mud – except at the Square Lake inlet. Here, *S. emarginatus* (*mighelsi*) could also be found in a marsh behind a lakeshore beach, in just a few cm of water among relatively dense emergent vegetation (mainly *Equisetum* sp.), on sand but with significant organic material as well. Several live specimens were found in this dark habitat only by touch.

Comparing the entire freshwater snail fauna observed in this project to that of Nylander's time, a subjective interpretation was made of possible trends in snail species distributions (Table 7). *Valvata sincera* found by Nylander was not recovered in this study, but it is a deepwater species and we did not conduct dredging. Three other species were also not well-targeted by our collecting techniques, so their distribution status is designated as unknown. Reassuringly, most freshwater snail species found by Nylander are still present, and have suffered no obvious contraction of their distribution across the major lakes, possibly excepting *S. emarginatus* and *G. parvus*. Interestingly, two species appear to have become more widely distributed – *G. deflectus* and *F. californica*. Of course, this is not a quantitative comparison, so there may well be important distribution or population changes that have occurred but that remain undetected.

Table 7. Freshwater snails collected in the Fish River drainage by Nylander (1936, 1942) and in 2011, with arrows indicating possible changes in distribution.

Valvatidae	**trend**
Valvata sincera (Say, 1824)	**?**
Viviparidae	**trend**
Campeloma decisum (Say, 1817)	↔
Hydrobiidae	
Amnicola cf *limosa* (Say, 1817)	↔
Lymnaeidae	
Fossaria cf *modicella* (Say, 1825)	**?**
Fossaria cf *obrussa* (Say, 1825)	**?**
Stagnicola cf *emarginatus* (Say, 1821)*	↓
* includes *S. e. mighelsi* (W.G. Binney, 1865)	
Physidae	
Physa ancillaria (Say, 1825)	↔
Physa gyrina (Say, 1821)	↔
Planorbidae	
Gyraulus deflectus (Say, 1824)	↑
Gyraulus parvus (Say, 1821)	↓
Helisoma anceps (Menke, 1830)	↔
Planorbella campanulata (Say, 1821)	↔
Planorbella trivolvis (Say, 1817)	↔
Promenetus exacuous (Say, 1821)	**?**
Ancylidae	
Ferrissia cf *californica (fragilis)* (Rowell, 1863)	↑

There were three species each encountered at only one site in this study – *Fossaria* cf *modicella*, *Promenetus exacuous*, and *Fossaria* cf *obrussa*. All three of the species are common across northern forest aquatic habitats in North America (Clarke, 1981; Jokinen, 1992). Although these animals were uncommon in this study, they are very small (<10mm) and typically live among emergent vegetation, rather than the open lakeshore habitats targeted here. Nylander (1936) reported *P. exacuous* from only Square Lake inlet and Portage Lake, while *F. obrussa* was "quite common," and he did not report *F. modicella*. Sampling targeting specific habitats for these small animals would be needed to properly determine their state status.

Recommendations

1) Search more thoroughly at Mud Lake, Cross Lake, and Portage Lake, to confirm whether *S. emarginatus* has been extirpated from these water bodies.

2) Inventory historic snail sites at Brassua Lake, Sebago Lake, Pushaw Pond, the Penobscot River (especially near Orono), the Fish River, and the St. John River, to determine whether *S. emarginatus* (forms *mighelsi* and *oronoensis*) persist at these locations.

3) Inventory freshwater snails in other lake and river systems in Maine, with special attention to *S. emarginatus* in the upper Allagash River and St. Johns River lakes, and the Penobscot River.

4) Expand and improve water quality measurements (including pH; important minerals such as Ca and Mg; and possible pollutants such as N, P, and selected toxins) in conjunction with further freshwater snail inventory.

5) Continue to encourage and support science education and natural history programs at local institutions such as the Nylander Museum.

Acknowledgements

This project was made possible by the generous contributions of Mainers to the Maine Outdoor Heritage Fund. I thank the MOHF board and staff for their work.

I am grateful to Jonathan Mays of Maine Dept. of Inland Fish & Wildlife's Reptile, Amphibian, and Invertebrate Group for his guidance and for IF&W's endorsement and support of this study.

Jeanie McGowan, Director of the Nylander Museum, provided logistical support and access to museum resources; and Nylander Museum trustee Deborah Nichols kept us fed and arranged housing for several days. We thank them for their immeasurable moral support as well.

Thanks to field crew members Trenton V. Bonney and Marian Hotopp for their company and efforts in the field, and to Judith Roe, PhD, for collection help at Long and Cross Lakes. Thanks also to Roy Bouchard, Maine Dept. of Environmental Protection's Lakes Assessment Program for making water quality data available.

Citations

Baker, F.C. 1911. The Lymnaeidae of Middle and North America, Recent and Fossil. Chicago Academy of Sciences, Special Publication No. 3, 539pp.

Burch, J.B. and J. L. Tottenham. 1980. North American freshwater snails: species list, ranges, and illustrations. Walkerana 3:81-215.

Burch, J.B. 1982. North American freshwater snails: identification keys, generic synonymy, supplemental notes, glossary, references, index. Walkerana 4:217-365.

___. 1988. North American freshwater snails: introduction, systematic, nomenclature, identification, morphology, habitats, distribution. Walkerana 6:1-80.

Clarke, A.H. 1981. *The Freshwater Molluscs of Canada*. National Museum of Natural Sciences, National Museums of Canada. Ottawa. 446pp.

Dillon, R.T., Jr. 2000. *The Ecology of Freshwater Molluscs*. Cambridge University Press, New York. 509pp.

___. 2006. Freshwater Gastropoda. *In*: C.F. Sturm, T.A, Pearce, and A. Valdes. (Eds). *The Mollusks: A Guide to their Study, Collection, and Preservation*, American Malacological Society, Universal Publishers, Boca Raton. pp251-259.

U.S. Environmental Protection Agency. 2012. MyWATERS Mapper. Online resource available:http://watersgeo.epa.gov/mwm/?layer=LEGACY_WBD&feature=01010003&extraLayers=null.

Hubendick, B. 1951. Recent Lymnaeidae: their variation, morphology, taxonomy, nomenclature, and distribution. Kungl Svenska Vetenskapsakad Handl (4) 3: 1-223.

Jokinen, E.H. 1992. The Freshwater Snails of New York State. New York State Museum Bulletin 482. Albany. 112pp.

Maine Dept. of Inland Fisheries & Wildlife. 2012. Maine Lake Survey Maps. Online Resource Available: http://www.state.me.us/ifw/fishing/lakesurvey_maps/aroostook/index.htm.

Martin, S.M. 1995. Maine's early malacological history. Maine Naturalist 3(1):1-34.

___. 1999. Freshwater snails (Mollusca: Gastropoda) of Maine. Northeastern Naturalist 6(1):39-88.

New England Integrated Sciences and Assessment. 2012. University of New Hampshire. Online resource available: http://neisa.unh.edu/Climate/IceOut.html.

Nylander, O.O. 1914. *Lymnaea emarginata mighelsi* absent in its old localities. Nautilus 28(8):95

___. 1921. The type localities of *Lymnaea emarginata* Say and *L. ampla* Mighels. Nautilus 34(3):77-80.

___. 1936. Land and freshwater shells of Aroostook County, Maine. Unpublished manuscript. 23pp.

___. 1942. Lymnaea of northern Maine. Report NYW0054 of the Nylander Museum, Caribou, Maine. 17pp.

NatureServe. 2011. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, Virginia. Online Resource Available http://www.natureserve.org/explorer.

Pip, E. 2000. The decline of freshwater mollusks in southern Manitoba. Canadian Field Naturalist 114:555-560.

Roy, D.C. 1987. Geologic map of the Caribou and northern Presque Isle 15' quadrangles, Maine. Open-File 87-2. Maine Geological Survey, Dept. of Conservation, 44pp +map.

Turgeon, D.D., J.F. Quinn, Jr., A.E. Bogan, E.V. Coan, F.G. Hochberg, W.G. Lyons, P.M. Mikkelsen, R.J. Neves, C.F.E. Roper, G. Rosenberg, B. Roth, A. Scheltema, F.G. Thompson, M. Vecchione, and J.D. Williams. 1998. Common and scientific names of aquatic invertebrates from the United States and Canada: Mollusks. 2nd Edition. American Fisheries Society Special Publication 26, Bethesda, Maryland: 526 pp.

Appendices

Appendix 1. Freshwater snails collected in the Fish River Lakes, Aroostook County, Maine. MS Excel spreadsheet.

About Appalachian Conservation Biology

ACB is a small environmental consulting company specializing in the biogeography, ecology, and conservation of invertebrates, especially land snails. Other work includes butterflies, freshwater snails, natural areas planning, rare plant inventory, old growth forest research, and native grassland, wetland, and forest restoration.

The company is owned and operated by conservation biologist Ken Hotopp. Ken started ACB in 1997 in western Maryland, and since 2005 has been located in Bethel, Maine. ACB projects are conducted with specially-assembled teams of collaborators and subcontractors, with field activities ranging from Maine to western Virginia. Clients are often state and federal agencies, but also include non-profit conservation groups, private landowners, and other environmental consulting firms.

The Appalachian Mountains of North America stretch from Georgia to the Gaspé Peninsula. They were created by the collision of continental "plates" of the earth's crust starting 650 million years ago. These mountains hold many forest, glade, and stream habitats that are home to a fantastic variety of plants and animals. The damp shady coves of the southern Appalachians are the center of diversity for eastern hardwood trees, salamanders, land snails, and other biota that have repeatedly spread outward and retreated in the wake of continental ice sheets.