Terrestrial snails as indicators of the health of the decomposer part of the ecosystem in Parks in Alberta.

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Abstract: Land snails are a part of the decomposer group of organisms in the upper part of the soil which is normally ignored when considering Parks management. The land snails consist of a relatively small number of species that entered the area after the last glaciation, following the northward migration of the boreal forest, and also a second even rarer group of species that entered the area during the Hypsithermal event. Ecologically, the snails can be divided into four groups, viz., the turf species, the duff species, the wetland species and the generalists. They can only survive along the galleria forest along the main rivers, and in areas with trees or tall grass prairie up to about 1900 m elevation. Frequent ground fires largely destroy the terrestrial molluscan fauna in the grassland sites. Duff faunas are less affected. During revegetation, generalists may invade the area together with the duff specialists that will become dominant after a suitable organic layer has become established on the forest floor. Wetland species often survive fire. Other major threats are destruction of habitat, introduction of non-native vegetation, development of recreational parks, urban and resource development and agriculture.

Introduction.

An ecosystem is a balanced group of plants and animals making up the biota in a given microenvironment and interacting with the abiotic features of that microenvironment (Tansley, 1935). Many members of the biota produce organic matter that falls to the ground, thus providing sustenance for other members that specialize in decomposing it. This decomposition goes on in the upper layers of the soil that is referred to as the litter (L), fermentation layer (F) and humus (H) at the surface of the mineral soil in Canada (NRRC, 1998). The decomposers consist of a large number of small plants and animals, and one of the minor groups is the terrestrial snails. Most of the decomposers can only be studied by rather laborious methods, whereas the snails are rather easier to work with, and involve a reasonable number of taxa.

The Parks in Alberta include those termed “natural areas” where the area is supposed to be maintained in its natural state. Inevitably, there is also a need for recreation for people, and conflicts arise in which the natural area tends to lose out. Furthermore, even in National Parks, more attention is paid to the well-being of the more obvious species such as elk, bears, caribou, trees, fish, etc., than the health of the smaller, inconspicuous species including the decomposers, which are commonly ignored. This can have the effect of extirpating species and upsetting the balance in the ecosystem. This paper will examine effects of some common management practices on the terrestrial snails, which are also a good indicator of what may be happening to the other decomposer species.

Past work on Terrestrial snails.

1. History.

North American terrestrial snails were studied long before settlement occurred in the southern part of Alberta. Binney had produced a manual of the known species by the middle of the 19^{th} century (Binney and Gould, 1851; Binney, 1878; 1885). The first collections in the south of Canada were made by the expedition studying the boundary with the United States, and additional collections were made by G. M. Dawson (1875) and J. Macoun in the area around Lake Louise before the coming of the CPR. These indicated a rich fauna along the floors of the mountain valleys. When the railroad was constructed in 1893, the construction workers and the prospectors destroyed much of the vegetation (Burns, 1968). In 1890, the CPR had built a wooden Lodge at the east end of Lake Louise (Lothian, 1979, pp. 27-28) and the damage to the nearby landscape along the Bow River persuaded the CPR to protect its investment by supporting the establishment of the Lake Louise reservation, which was established in 1892. Ten years later, this was incorporated into what is now the Banff National Park. Since then, Parks management has tried to suppress fires and permit the recovery of the forests, though this policy appears to have changed during the last decade.

The construction of the railroad in 1883 appears to have resulted in the extirpation of several species of land snails in the area around Lake Louise (*Gastrocopta armifera* Say (1821), *G. holzingeri* Sterki (1899), *G. pentodon* Say (1821), *and G. similis* Sterki (1909)). Of these, the first two have not been found elsewhere in the Province. The Bow River valley has the most diverse snail fauna in southern Alberta (Figure 1) and the loss of these species from the Lake Louise area is almost certainly due to the loss of habitat during the construction of the railroad.

Harris (1973) gave a preliminary summary of the distribution of land snails in relation to vegetation zonation and altitude across southern Alberta, and there are a number of other studies of snail distribution in the Province, e.g., near Jasper (Mozley, 1926a; 1926b; 1930; Platt, 1980), Edmonton (Van Es and Boag, 1981), the Cypress Hills (Russell, 1951), and in the Sheep River area (Boag and Wishart, 1982). Altogether, some 75 taxa are currently known to be present. Lepitzki (2001) provides a first estimate of the risk of extirpation of some of them, while some S-Ranks will be found in Alberta natural Heritage Information Centre (2002) for those species known to be present by them at that time.

2. **History of migration after deglaciation.**

Almost all of Alberta was covered by the Late Wisconsin ice sheets, but about 11ka, the boreal forest started its migration northwards from the unglaciated parts of Montana and the first land snails followed the migration. The earliest record is of *Vertigo ovata* Say (1822) in the alluvium around Glacial Lake Sundre at about 10ka (Boydell, 1973). The climate was warm but moist, but large masses of stagnant ice limited the area available for migration of terrestrial species to the southwest portion of the area (Harris, 1985). By the time of the deposition of the Mazama Ash (c. 6830 years BP), a well-developed terrestrial fauna was present along the Oldman River valley (Harris and Pip, 1973), and is presumed to have migrated

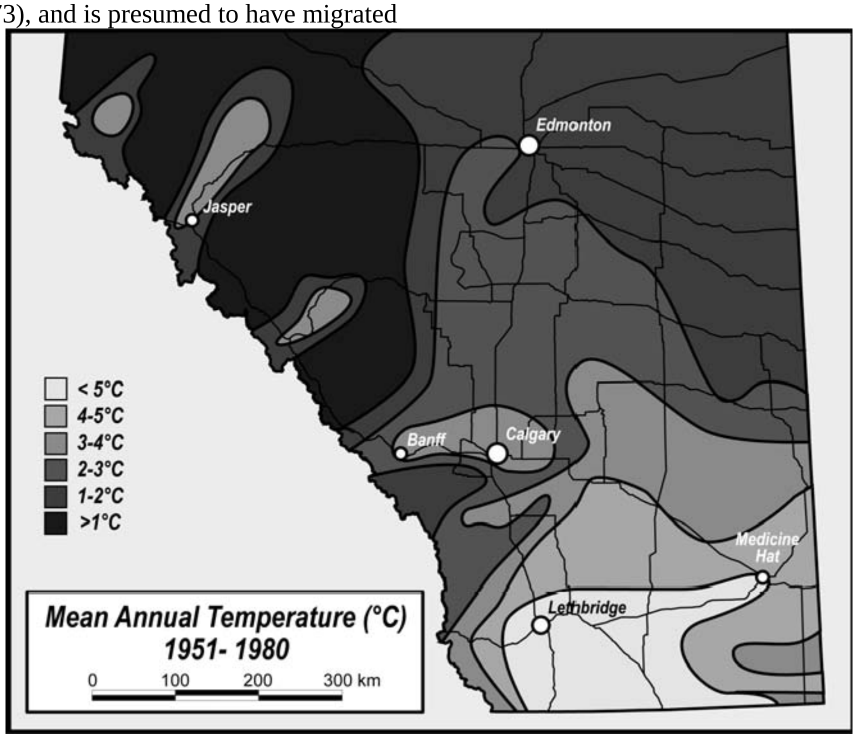

Figure 1. Mean Annual Air Temperature in southern Alberta (!951-1980), based on AES 1993..

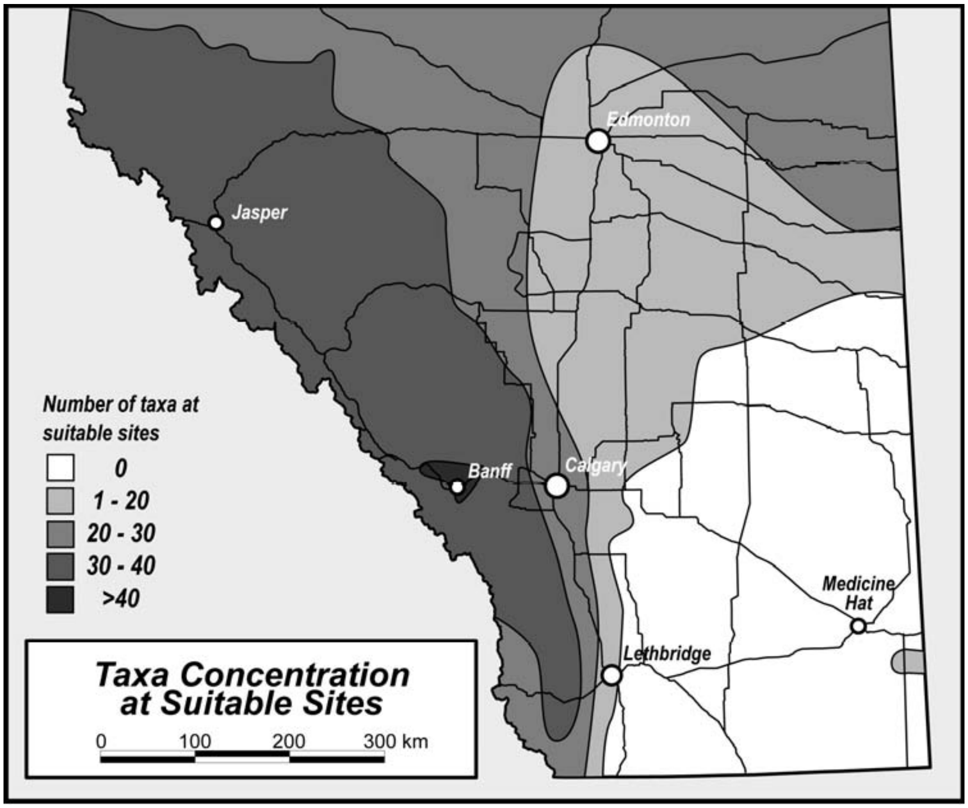

Figure 2. Number of species present at suitable sites across southern Alberta.

northwards through northern Alberta. This was followed by the hot, dry Hypsithermal event which culminated about 6ka, lasting until about 4ka. During this period, a number of species now generally found in warmer climates further south, migrated along the riparian woodlands on the floodplains of the major river valleys, across the Prairies to reach places like Lake Louise. They included the *Gastrocopta* species mentioned above. Others migrated north or through the Crowsnest Pass and are occasionally found in southwest Alberta, but are very rare, e.g., *Anguispira kochi occidentalis* Pfeiffer (1821), *Oreohelix strigosa* Gould (1846) and *Oreohelix subrudis* Reeve (1854). When the climate cooled and the Neoglacial cold fluctuations began, these species largely died out except for a few isolated occurrences where the microenvironment permitted their survival. They are the species most at risk of extirpation in the Province.

3. Ecology.

The terrestrial molluscs are dependent on moisture conditions, availability of food and on climate for their survival. In general, the short grass prairies lack land snails except where permanent water bodies are found and along the major river valleys. The snails become more common and diverse as they are traced into the foothills and mountains, being particularly abundant in the areas with strong Chinook winds and warmer temperatures (compare Figures 1 and 2). The relationship of part of the molluscan fauna to the major vegetation zones and to altitude at the latitude of Calgary is shown in Table 1.

The snails can be divided into four groups. The turf specialists, e.g., *Vallonia parvula* Sterki (1892) and *Zonitoides nitidus* Müller (1774), that are found primarily in the grasslands (Nekola, 2002), i.e., the areas of tall grass prairie, the parkland, and in the grassy openings in the outer portion of the mixed coniferous and deciduous forest. The duff specialists, e.g., the *Vertigo* species, live in the organic layers of the soil, eating organic matter, so they are mainly found in the lower parts of the forest below 1900 m. Along the margins of lakes and ponds and along the flood plains of the major rivers are found the wetland species including the species of the genera *Catinella* , *Oxyloma* and *Succinea*. These can be found at wet sites thoughout the area. Finally, there are the generalists that can survive under a wide variety of conditions, e.g., *Zonitoides arboreus* Say (1816). In Table 1, the generalists are seen to have the maximum altitudinal range, although terrestrial mollusca have not been collected on the upper mountain slopes.

Effects of disturbance of the ecosystem on the terrestrial snails.

Disturbances come in several forms, e.g., seral changes, fire, destruction of habitat, introduction of non-native vegetation and agriculture in its various forms. All these have occurred in the "natural area parks". They will be dealt with here separately, though in practice, several of these may be involved in affecting the molluscan distribution in any given case.

1. Seral changes.

Vegetation goes through a series of changes to reach the final equilibrium stage for a given environment. Any major disturbance such as fire causes a new vegetation cover to grow. This vegetation also goes through a series of stages until it reaches an equilibrium condition. In the boreal forest in Alberta regeneration after fire commences with the growth of lodgepole pine and a small number of shrubs and herbs. This provides suitable nursery conditions for other shrubs and herbs as well as spruce and alpine fir (Harris, 1976; Chernoff, 2001). In theory, the pine dies off after about 80 years to be replaced by a cover of spruce and fir. In practice, the lodgepole pine along the Bow valley is surviving longer than predicted by the theory, and it now appears that an infestation of pine bark beetle may be necessary to cause the switch to the spruce-fir climax forest. Note that suppression of the pine bark beetle may interfere with the establishment of the original climax forest. In the tall grass prairie, the grasslands owed their existence to frequent fires, low precipitation and to grazing (Weaver, 1954). When such areas are used for cattle ranching or Parks with suppression of fires, the grasslands gradually change to Parkland and even mixed deciduous and coniferous forest. Examples can be seen just west of the junction of the TransCanada Highway at Highway 22, at the 2 acre experimental plot on Campus, and on the slopes of Nose Hill Park.

The generalist and duff snails will be the first species to colonize the new environment, with the duff species becoming dominant when there is a suitable litter layer. The floristic composition of the forest affects the results since snails are particularly abundant in the litter beneath trembling aspen. There is reason to think that the species composition and species of the land snail fauna changes with the changes in the vegetation (Table 1). Unfortunately, there are no quantitative studies of these changes in Alberta.

2. Fire.

Fire is a serious threat to the decomposers in the soil. It is most damaging in the case of ground fires in tall grass prairie grasslands, where 72% of the species were found to be negatively affected in the Central American grasslands (Nekola, 2002). Reductions of the order of 75% in numbers of individuals were normal. Fire was always an important factor in the maintenance of the prairie grasslands, but it is also the reason that they were largely lacking in land snails (Weaver, 1954; Curtis, 1959). Quantitative studies show that fire produces a decrease in overall snail abundance (Berry, 1973), snail diversity (Cain, 1983; Locasciulli and Boag, 1987) and composition (Cameron and Morgan-Huws, 1975; Bauer et al., 1996; Barker and Mayhill, 1999), which is closely related to depth of litter. Fire removes the surface soil organic layer, and has been implicated in the reduction in numbers of both land snails (Hawkins et al., 1998) and numerous other native prairie invertebrate species (Harper et al., 2000).

The quantitative studies by Nekola (2002, Table 2) in northwestern Minnesota and northeastern Iowa, showed that out of 72 species collected, 32 showed a significant reduction in occurrence after fire, while only six species showed a positive response. Of these, only one was a turf specialist in that area (*Vallonia parvula,* Sterki, 1892), while two were generalists (*Vallonia costata,* Müller, 1774, and *Vertigo pygmaea,* Draparnaud, 1801).

The short grass prairie areas generally lacked mollusca, except around water bodies and along the floodplains of the major rivers where the generalists and duff specialists could thrive. It seems likely that land snails and other native grassland invertebrate groups in the pre-settlement landscape may have been able to survive regular fires by recolonizing the burned areas from source pools in adjacent unburned areas. However the recolonization may take more than twelve years under present climatic conditions (Mand et al., 2001). In the southern Plains grasslands of the United States, recovery of the organic detritus to pre-fire levels takes at least 5 years (Kucera and Koelling, 1964). In more northern locations, the recovery takes much longer (Hill and Platt, 1975). Given the fragmentation of suitable source areas by agricultural, urban, recreation and forestry development, it is likely that turf specialists will continue to decline in numbers and diversity.

In wetland prairie communities in Oregon, Severns (2005) found that fire decreased species richness, but the abundance of individuals increased to above pre-fire numbers after about three years. *Monadia fidelis* was extirpated but *Catinella rehderi* Pilsbry (1948) and *Vertigo modesta* Say (1824) were indicator species of burning. Both the latter species are common in Alberta.

Fire was found to be least damaging in the case of forests in Minnesota, where 67% of the molluscan species were not obviously affected (Nekola, 2002). The snails live in the upper 5 cm of the duff, and if that survives, then the effects of heat may be limited. If the duff burns, the biota living in it will be incinerated, including all the snails. Rate of recolonization after fire in Alberta is unknown. The generalist and duff woodland taxa may be protected by the mass effect of the snail population in the suurounding forest, which may aid in the recolonization process (Schmida and Ellner, 1984). In all environments, fire most strongly impacts the rarest species, which may become extirpated by frequent use of prescribed burns.

3. Destruction of Habitat.

This is now becoming the greatest threat to the survival of terrestrial mollusca . One of the most widespread causes is logging of timber. This removes the habitat, which will cause the extirpation of all but the most resilient generalists of the fauna in the affected area. Scarification of the surface soils, soil erosion and burning of the trash alter the microenvironment, resulting in the bare soils becoming drier and hotter. Unfortunately there do not seem to be any published studies of the changes. This is important in the areas of widespread logging of the slopes of the Rocky Mountains.

When Alberta Parks establishes Provincial Parks away from the mountains, the sites selected are usually along streams or on the shores of lakes. At Elkwater Lake, the south shore was largely relandscaped, resulting in a severe loss of habitat for the molluscs that used to inhabit the shore. This has resulted in the loss of those species from that area. A similar fate would appear to await the rare snails inhabiting the area to be developed as a major holiday resort in the Crowsnest Pass. The area is the main location for *Anguispira kochi occidentalis* Pfeiffer (1821), *Oreohelix strigosa* Gould (1846) and *Oreohelix subrudis* Reeve (1854) in Alberta, although some isolated occurrences of these species may be present along the foothills south to Waterton National Park. Fortunately, these species also occur in Montana and in southern British Columbia..

Other causes of loss of habitat include development of areas for housing, open-pit mining, and the grazing of cattle in the Foothills. The first two causes result in complete loss of the habitat, whereas cattle grazing results in changes to the vegetation and may also cause losses by trampling. There is a tendency for areas cleared of timber to be used for grazing. The cattle chew the young coniferous trees and tend to prevent or seriously modify reforestation. Where coniferous trees are replanted, they tend to be of a single, fast-growing species which alters the microenvironment. Any modification of the architecture of the top 5 cm of the soil profile, e.g., by scarification, will cause problems for the duff specialists (Cameron, 1986).

4. Introduction of non-native vegetation.

The native fauna evolved together with the native vegetation and is adapted to co-existing with it. In Little Bow Provincial Park, there has been replacement of several hectares of native vegetation by exotic grasses. The native mollusks had evolved to co-exist with the native vegetation, and the changes have resulted in the local extirpation of the terrestrial molluscan fauna. The change to a highly manicured camping area together with the changes in vegetation have resulted in the extirpation of most native terrestrial molluscan species in that area.

5. Agriculture and development.

These changes result in fragmentation of the natural environments making recolonization of any damaged areas difficult, if not impossible for terrestrial mollusca. Just as the patchy protection of the eastern slopes of the mountains is disrupting migration corridors for large mammals, the former extensive areas of forests and prairie grasslands have been chopped up into little isolated patches.

Large areas of the prairies have been modified by farming of various kinds. Probably the least intrusive use is ranching since the cattle generally have free range as did the buffalo bison several decades earlier. The main differences are the choice of food by the cattle, the intensity of use, and the planting of exotic grasses periodically to improve the pasture. Ploughing and reseeding have a similar effect to growing crops, except that nutrients are not removed as they are with arable farming. However intensive cattle ranching may result in changes in the available nutrients such as nitrogen. The use of herbicides and pesticides makes the land inhospitable for molluscs, and these chemicals may travel away from the point of application, either in the wind or in surface or subsurface waters. They can therefore render surrounding areas and places downslope barren of mollusca. This has resulted in the extirpation of snails from considerable areas of the floodplains of the major rivers, which is particularly important for the rare species that entered the area during the Hypsithermal period. Thus *Gastrocopta similis* Sterki (1909) can only be found at one of the three sites where it had been collected previously, although it can still occurs at one relatively inaccessible site along the North Saskatchewan River in Saskatchewan. In the case of Fort Normandeau Provincial Park, it is unclear whether the introduction of exotic grasses or the use of chemicals is the cause of the extirpation of this species. A major migration of terrestrial mollosca up the river floodplains in the event of climatic warming is now virtually impossible.

At least as important is the alteration of the prairie by irrigation farming. This has occurred in large areas of southern Alberta, and results in flooding of some formerly dry areas together with reduced flows on the rivers. In general, the new associated wetlands increase the available environments for the snails that live alongside water, provided the water is not too saline. The building of dams can cause cessation of periodic flooding of the flood plains that is essential for the Cottonwood trees to flourish. Their demise along the Milk River is altering the ecosystem and this may cause loss of species. Similarly, the use of water for habitations along the major rivers such as the Bow River alters its chemical composition which can result in problems for the biota.

Conclusions.

The terrestrial molluscs are but one of a whole group of relatively inconspicuous organisms that are important in decomposing organic matter, reducing the fuel that makes forest fires more intense, and bringing about a recycling of the nutrients locked up in decaying organic matter. Since they can readily be monitored, they are convenient indicators of the health of the decomposer part of a given ecosystem. If that part is not functioning well, then there will be problems with the build-up of fuel that will make forest fires more intense and potentially more frequent. In addition, the lack of attention being paid to this group of organisms may result in their irreversible extirpation from the ecosystem. For these reasons, managers should pay more attention to the effects that their management practices may have on the decomposers in the ecosystems that they are dealing with.

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Table .

Group	Species	Tall grass Prairie	Riparian Forest	Parkland	Mixed Deciduous and coniferous forest	Subalpine coniferous forest
Duff	*Carychium exile*ssp. *canadense*Clapp (1906)				X	X
	Microphysula ingersollii Bland (1875)				X	X
	Punctum minutissimum I. Lea (1841)				X	X
	Punctum randolphii Dall (1885)				X	X
	Hawaiia miniscula A. Binney (1840)					X
	Gastrocopta pentodon Say (1822)				X	X
	Gastrocopta similis Sterki (1909)				X	X
	Columella columella von Martens (1830)			X	XX	X
	Columella edentula Draparnaud (1805)			XX	X	X
	Vertigo milium Gould (1840)				X	X
	Vertigo arthuri von Martens (1882)		X	XX	XX	X
	Vertigo basidens Pilsbry and Vanetta (1900)					X
	Vertigo concinnula Cockerell (1897)				X	X
	Vertigo criststa Sterki (1919)					X
	Vertigo gouldi coloradensis Cockerell (1891)			X	XX	X
	Vertigo paradoxa Sterki in Nylander (1900)				X	X
	Vertigo arctica Wallenberg (1858)			X	XX	XX
	Vertigo modesta Say (1824)			X	XX	XX
	Vertigo binneyana Sterki (1890)					X
	Vertigo morsei Sterki (1894)					X
	Vertigo ovata Say (1822)			X	X	X
	Vertigo ventricosa Morse (1865)				X	X
	Vitrina pellucida Müller (1774)			X	XX	X
Generalists	*Anguispira kochi occidentalis* Pfeifer (1821)				X	X
	Discus shimekii Pilsbry (1890)			X	XX	XXX
	Discus whitneyi Newcomb	X	XX	XX	XX	XX

	(1864)					
	Euconulus fulvus alaskensis Pilsbry (1899)		X	XX	XX	XX
	Euconulus fulvus fulvus Müller (1774)		X	XX	XX	XX
	Euconulus polygyratus Pilsbry (1899)		X	X	XX	X
	Euconulus praticola Reinhardt (1883)		X	XX	XX	XX
	Zonitoides arboreus Say (1816)		XXX	XXX	XXX	XXX
	Zonitoides nitidus Müller (1774)			XX	XX	XX
	Nesovitrea binneyana binneyana Morse (1864)			X	XXX	XX
	Nesovitrea electrina Gould (1841)			X	XX	X
	Nesovitrea occidentalis H. B. Baker (1930)		X	XX	XX	X
	Vitrina angellicae Beck (1837)		XX	XX	XX	X
	Cochlicopa lubrica Müller (1774)	X	X	XX	XXX	X
	Vallonia cyclophorella Sterki (1892)			X	XXX	XX
	Vallonia gracilicosta Reinhardt (1883)	XX	XXX	XXX	XX	X
	Vallonia parvula Sterki (1893)	X	XX	XXX	XX	X
	Vallonia pulchella Müller (1774)	XX	XX	XX	X	X
Turf	*Punctum californicum* Pilsbry (1898)			X		X
	Zoögenetes harpa Say (1824)			X	XX	X
	Vallonia costata Müller (1774)			X		XX
	Vallonia excentrica Sterki in Pilsbry (1893)	X		XXX	XX	X
	Pupilla blandi Morse (1865)			X		X
	Pupilla hebes Ancey (1881)	X		XX	XXX	X
	*Pupilla muscorum*Linnaeus (1758)			X		X
Wetlands	*Catinella rehderi* Pilsbry (1948)				X	X
	Oxloma hawkinsi Baird (1863)				X	X
	Oxyloma haydeni Binney (1858)			X	X	X
	Succinea indiana Pilsbry (1905)		X	XX		X